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**JOURNAL
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SOUTH AFRICAN
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Prof. H. B. Rycroft

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Harold Pearson Professor of Botany, University of Cape Town).

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CONTENTS

	<i>Page</i>
A PRELIMINARY CHECK LIST OF THE FLORA OF INHACA ISLAND, MOÇAM- BIQUE: BASED ON THE COLLECTION OF A. O. D. MOGG. J. Munday and P. L. Forbes	1
THE MORPHOLOGY OF <i>ACACIA REDACTA</i> J. H. ROSS. P. J. Robbertse and I. von Teichman	11
A CHECK LIST OF FERNS AND FLOWERING PLANTS OF THE SUIKERBOSRAND NA- TURE RESERVE. G. J. Bredenkamp and A. v. W. Lambrechts	25
AN ANNOTATED SYSTEMATIC CHECK LIST OF THE ANGIOSPERMAE OF THE WOR- CESTER VELD RESERVE. M. C. Olivier ...	49
DIE ANATOMIE EN ULTRASTRUKTUUR VAN DIE EKSTRAFLORALE NEKTARKLIERE VAN <i>DIOSCOREA SYLVATICA</i> ECKL. EN DIE SAMESTELLING VAN DIE NEKTAR. I. von Teichman und Logischen en P. J. Rob- bertse	63
A NOTE ON THE STATUS OF <i>CARALLUMA</i> <i>ORTHOLOBA</i> LAVRANOS (ASCLEPIA- DACEAE). P. V. Bruyns	79
NEW SPECIES OF CAPE IRIDACEAE. P. Goldblatt	81
BOOK REVIEW: <i>New natural products and plant drugs with pharmacological, biological or therapeutical activity</i> , edited by H. Wagner and P. Wolff (C. W. Glennie)	91
ANNOUNCEMENTS	92
POLLEN MORPHOLOGY OF SOUTH AFRI- CAN MALVALES:	
1. CHARACTERISTICS USEFUL FOR KEY- ING AND FOR NUMERICAL ANALYSIS. J. Coetsee and H. P. van der Schijff	93
NOTES ON <i>TULBAGHIA</i> : 1. A NEW SPECIES FROM THE EASTERN CAPE AND A LIST OF NEW LOCALITIES. C. G. Vosa	127
APPARENT TRANSPIRATIONAL RHYTHMS OF <i>AVICENNIA MARINA</i> (FORSK.) VIERH. AT INHACA ISLAND, MOÇAMBIQUE. T. D. Steinke	133

	Page
THE ORIGIN OF THE BOUQUET ARRANGEMENT OF PROPHASE CHROMOSOMES IN <i>ALLIUM CEPA</i> . D. J. Mogford ..	139
STUDIES IN THE GENERA OF THE <i>DIOSMEAE</i> (RUTACEAE): 8. I. Williams	147
FLAVONOID GLYCOSIDES OF <i>LEUCOSPERMUM</i> R. BR. C. W. Glennie	185
TEN MORE NEW SPECIES OF <i>LACHENALIA</i> (LILIACEAE). W. F. Barker	193
A NEW NAME FOR <i>BLECHNUM CAPENSE</i> (L.) SCHLECHTEND. E. A. C. L. E. Schelpe	221
A NEW SPECIES OF <i>TAPINANTHUS</i> (LORANTHACEAE). H. R. Tölken	223
BOOK REVIEWS: <i>Grassland simulation model</i> , edited by G. S. Innes (W. L. J. van Rensburg). <i>Incompatibility in Angiosperms</i> , by D. de Nettancourt (N. van Schaik). <i>The biology of Lichens</i> , by Mason E. Hale (W. J. Lütjeharms)	227
ANNOUNCEMENT	229
EFFECT OF VARYING CARBOHYDRATE LEVELS ON THE UPTAKE AND TRANSLOCATION OF ³² P IN <i>ERAGROSTIS CURVULA</i> (SCHRAD.) NEES. G. Naidoo and T. D. Steinke	231
THE DUAL MECHANISM OF IRON ABSORPTION IN BEAN ROOT AND LEAF TISSUES. J. H. Jooste and J. A. de Bruyn	243
DESORPTION OF ABSORBED IRON IN BEAN ROOT AND LEAF TISSUES. J. H. Jooste and J. A. de Bruyn	249
COMPARISON OF IRON UPTAKE BY BEAN ROOT AND LEAF TISSUES. J. H. Jooste ..	257
A TECHNIQUE FOR THE FLUORESCENCE STAINING OF FUNGAL NUCLEI. D. J. Mogford	263
A QUALITATIVE STUDY OF THE NODULATING ABILITY OF LEGUME SPECIES: LIST 5. N. Grobbelaar and M. W. van Rooyen ...	267
A NEW SPECIES OF <i>EUGENIA</i> L. (MYRTACEAE) FROM SOUTHERN NATAL AND TRANSKEI. A. E. van Wyk	273
PHENOLOGY OF THE VEGETATION IN THE HESTER MALAN NATURE RESERVE IN THE NAMAQUALAND BROKEN VELD: 1. GENERAL OBSERVATIONS. M. W. van Rooyen, G. K. Theron and N. Grobbelaar ..	279
THE AFRICAN GENUS <i>FERRARIA</i> . M. P. de Vos	295

	Page
NOTES ON THE NOMENCLATURE OF <i>PELARGONIUM</i> (GERANIACEAE). J. J. A. van der Walt	377
BOOK REVIEWS: <i>Bibliography of South Afri- can botany (up to 1951)</i> , by A. A. Bullock, edited by O. A. Leistner (J. P. Rourke). <i>Greenhouse management</i> , by J. J. Hanan, W. D. Holley and K. L. Goldsberry (G. Jacobs). <i>Medicinal plants of West Africa</i> , by Edward S. Ayensu (W. P. U. Jackson). <i>Theories and techniques in vegetation analysis</i> , by R. E. Randall (B. M. Campbell)	381
BIOLOGY AND SYSTEMATICS OF <i>GALAXIA</i> (IRIDACEAE). P. Goldblatt	385
CHARACTERIZATION OF PECTIN ME- THYLESTERASE FROM MARVEL TO- MATOES. T. Theron and O. T. de Villiers ..	425
PHENOLOGY OF THE VEGETATION IN THE HESTER MALAN NATURE RESERVE IN THE NAMAQUALAND BROKEN VELD: 2. THE THEROPHYTE POPULATION. M. W. van Rooyen, N. Grobbelaar and G. K. Theron	433
SHOULD THERE BE MORE TREE VEGETA- TION IN THE MEDITERRANEAN CLIMATIC REGION OF SOUTH AFRICA? B. M. Campbell, B. McKenzie and E. J. Moll	453
THE ORCHID FLORA OF THE NYIKA PLATEAU. G. Williamson	459
NOTES ON <i>PROTEA</i> IN SOUTH AFRICA. J. P. Rourke	469
BOOK REVIEWS: <i>Flora of South Australia</i> , part 1, by J. M. Black, revised and edited by J. P. Jessop (P. Fairall). <i>An illustrated guide to pollen analysis</i> , by P. D. Moore and J. A. Webb (J. A. Coetzee). <i>Tropical trees and forest: an architectural analysis</i> , by F. Hallé, R. A. A. Oldeman and P. B. Tomlinson (D. G. M. Donald). <i>Physiology and biochemistry of seeds in relation to germination</i> , vol. 1: <i>De- velopment, germination and growth</i> , by J. D. Bewley and M. Black (N. Grobbelaar). <i>Pro- duction ecology of British moors and mon- tane grasslands</i> , edited by O. W. Heal and D. F. Perkins assisted by W. M. Brown (E. J. Moll)	473
ANNOUNCEMENT	479
INDEX TO PLANT NAMES: VOL. 45 (1-4) ...	481
Indexed in <i>Biological Abstracts</i> and <i>Current Advances in Plant Science</i>	



THIS VOLUME IS DEDICATED TO

ELSIE ELIZABETH ESTERHUYSEN (1912—)
M.A. (Cape Town)

Solly Scholar at Kirstenbosch for 1935 and botanist at the Bolus Herbarium, University of Cape Town, from 1938 until her retirement as Chief Assistant in 1977—an ardent mountaineer and plant collector, who, through her more than 35 000 meticulously documented collections, has contributed more to our knowledge of the mountain Flora in the Cape than any other person thus far this century. More recently she has taken a particular interest in the local Restionaceae, becoming an acknowledged expert in this field, devoting much attention to the collecting and recording of this group from lowland sites where habitats are fast disappearing through human population pressure. Although an innate modesty has often restrained her from publishing, Elsie Esterhuysen has generously and joyfully given of her prodigious field knowledge to a whole generation of colleagues. Indeed, without her assistance, the satisfactory completion of many papers on Cape-based plants would scarcely have been possible.

A PRELIMINARY CHECK LIST OF THE FLORA OF INHACA ISLAND, MOÇAMBIQUE: BASED ON THE COLLECTION OF A. O. D. MOGG

J. MUNDAY AND P. L. FORBES

(Moss Herbarium, Department of Botany and Microbiology, University of the Witwatersrand)

ABSTRACT

A check list of approximately 580 flowering plants and ferns collected on the island of Inhaca off Maputo, Moçambique, is given.

UITTREKSEL

'N VOORLOPIGE KONTROLELYS VAN DIE FLORA VAN INHACA-EILAND, MOSAMBIEK: GEBASEER OP DIE VERSAMELING VAN A. O. D. MOGG

'n Kontrolelys van ongeveer 580 blomplante en varings wat op die eiland Inhaca naby Maputo, Mosambiek, versamel is, word aangebied.

INTRODUCTION

Inhaca Island, 11 km by 6 km, is narrowly separated from the mainland of Africa. Together with Inhaca Peninsula, it forms the eastern arm of what is commonly known as Delagoa Bay. Small adjacent islands have also been included in this study. History, geography and biology have been described by Macnae, Kalk *et al.* (1958). Of particular interest to biologists are mangrove swamps and the extensive shallow sand flats on the sheltered west coast which provide a suitable environment for a number of marine angiosperms.

During past years, the interesting fauna and flora of Inhaca attracted many scientists including several groups from the University of the Witwatersrand. In the course of these visits a plant collection was made which is now housed in the Moss Herbarium. The chief collector was Dr A. O. D. Mogg.

There are still some species which have been poorly or inadequately collected. The political situation at present prevents further visits to the island. It has not been possible for the authors to re-collect critical species or to study living material in situ, but it was nevertheless decided to publish information already available as a preliminary check list hoping that it would be of value to those who have visited Inhaca in the past and as a basis for further work some time in the future. The list compiled by Mogg in Macnae, Kalk *et al.* (1958) is incomplete and now out of date.

A few species not present in the Moss Herbarium but which have been encountered in other herbaria have been included. With regard to contentious

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generic limits as in *Loranthus* and *Asclepias* and in Cyperaceae, the treatment of Dyer (1975 and 1976) has been followed.

Introduced species have been listed if they have become naturalised. *Casuarina equisetifolia* Forst. has been planted to stabilise sand dunes but it is not included.

It is interesting to note that a high proportion of the species listed here also occurs in Natal (Ross, 1972), particularly in Tongaland.

ACKNOWLEDGEMENTS

Sincere thanks are due to Mrs M. Macnae who did valuable preliminary sorting and naming of the collection. This check list is based on her work.

As the resources of the Moss Herbarium are limited with regard to the area of study, much help was received from the Botanical Research Institute, Pretoria, Natal University Herbarium, Pietermaritzburg and the Government Herbarium, Salisbury. We thank the staff of these institutions for their assistance.

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 ———, 1976. *The Genera of Southern African Flowering Plants*. 2. Pretoria: Department of Agricultural Technical Services.
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 ROSS, J. H., 1972. Flora of Natal. *Mem. bot. Surv. S. Afr.* 39.

PTERIDOPHYTA

PSILOTACEAE

Psilotum nudum (L.) Beauv.

OPHIOGLOSSACEAE

Ophioglossum polyphyllum A. Braun

MARSILEACEAE

Marsilea sp.

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn

ADIANTACEAE

Acrostichum aureum L.

Pellaea viridis (Forsk.) Prantl var.

POLYPODIACEAE

Phymatodes scolopendria (Burm.f.) Ching

Microgramma lycopodioides (L.) Copel.

ASPLENIACEAE

Asplenium aethiopicum (Burm.f.) Becherer

THELYPTERIDACEAE

Thelypteris sp. probably *T. gueinziana* (Mett.) Schelpe

T. totto (Thunb.) Schelpe

SPERMATOPHYTA

GYMNOSPERMAE

ZAMIACEAE

Encephalartos ferox Bertol.f.

ANGIOSPERMAE

MONOCOTYLEDONAE

TYPHACEAE

Typha latifolia L. subsp. *capensis* Rohrb. sensu PRE

ZOSTERACEAE

Zostera capensis Setchell

ZANNICHELLIACEAE

Cymodocea rotundata Ehrenb. & Hempr. ex Aschers.

C. serrulata (R.Br.) Aschers. & Magnus
Syringodium isoetifolium (Aschers.) Dandy
Thalassodendron ciliatum (Forsk.) den Hartog

Halodule uninervis (Forsk.) Aschers.

H. wrightii Aschers.

JUNCAGINACEAE

Triglochin striata Ruiz & Pavon

ALISMATACEAE

Limnophyton obtusifolium (L.) Miq.

HYDROCHARITACEAE

Halophila ovalis (R.Br.) Hook.f. subsp. *ovalis*

H. ovalis (R.Br.) Hook.f. subsp. *linearis* (den Hartog) den Hartog

Thalassia hemprichii (Ehrenb.) Aschers.

Ottelia ulvifolia (Planch.) Walp.

POACEAE (Gramineae)

Imperata cylindrica (L.) Beauv.

Ischaemum arcuatum (Nees) Stapf

I. afrum (Gmel.) Dandy

Urelytrum squarrosus Hack.

Hemarthria altissima (Poir.) Stapf & Hubb.

Andropogon eucomis Nees

A. huillensis Rendle

Cymbopogon validus Stapf ex Burt Davy

Hyperthelia dissoluta (Nees ex Steud.) W.D.Clayt.

Themeda triandra Forsk.

Perotis patens Gand.

Paspalum vaginatum Swartz

Panicum chusqueoides Hack.

P. deustum Thunb.

P. maximum Jacq.

P. subflabellatum Stapf

P. volutans J.G.Anders.

Urochloa mosambicensis (Hack.) Dandy

Brachiaria deflexa (Schumach.) C.E.Hubb. ex Robyns (sometimes placed under *Pseudobrachiaria deflexa* (Schumach.) Launert)

B. humidicola (Rendle) Schweick.

Sacciolepis curvata (L.) Chase

Digitaria abyssinica (Hochst. ex A.Rich.) Stapf

D. argyrotricha (Anderss.) Chiov.

Digitaria eriantha Steud.

D. gymnostachys Pilg.

D. longiflora (Retz.) Pers.

D. macroglossa Henr.

D. pentzii Stent

D. perrottetii (Kunth) Stapf

Tricholaena monachne (Trin.) Stapf & Hubb.

Rhynchelytrum repens (Willd.) C.E.Hubb.

Cenchrus biflorus Roxb.

C. incertus Curtis

Stenotaphrum secundatum (Walt.) Kuntze

Aristida barbicollis Trin. & Rupr.

A. stipitata Hack. var. *graciliflora* (Pilg.) de Wint.

Sporobolus subtilis Kunth

S. virginicus (L.) Kunth

S. sp.

Cynodon dactylon (L.) Pers.

Chloris virgata Swartz

Dinebra retroflexa (Vahl) Panz.

Dactyloctenium aegyptium (L.) Willd.

D. australe Steud.

D. geminatum Hack.

Schmidtia pappophoroides Steud.

Triraphis schinzii Hack.

Fingerhuthia africana Lehm.

Phragmites australis (Cav.) Trin. ex Steud.

Diplachne fusca (L.) Stapf

Eragrostis capensis (Thunb.) Trin.

E. chapelieri (Kunth) Nees

E. ciliaris (L.) R.Br.

E. heteromera Stapf

E. lappula Nees

E. moggii de Wint. var. *moggii*

E. moggii de Wint. var. *contracta* de Wint.

E. superba Peyr.

E. sp. aff. E. barrellieri Dav.

Megastachya mucronata (Poir.) Beauv.

CYPERACEAE

Lipocarpa paradoxa Cherm. (or *Mariscus paradoxus* (Cherm.) Cherm.)

Cyperus articulatus L.

C. immensus C.B.Cl.

C. margaritaceus Vahl

C. maritimus Poir.

C. natalensis Hochst. ex Krauss

C. obtusiflorus Vahl

C. papyrus L.

C. prolifer Lam.

C. sphacelatus Rottb. sens. lat.

C. sphaerospermus Schrad.

C. tenax Boeck.

Pycneus nitidus (Lam.) J.Raynal

P. pelophilus (Ridl.) C.B.C1.
P. polystachyus (Rottb.) Beauv.
Mariscus dubius (Rottb.) Hutch. (NOTE:
 The genus *Mariscus* is at present under
 revision)
 Probably *Mariscus macrocarpus* (Boeck.)
 Kunth
Mariscus thunbergii (Vahl) Schrad. sens.
 lat.
Fuirena microlepis sensu C.B.C1. in
 Thiselton-Dyer, Fl. Cap. 7: 262 (1898) et
 Illus. Cyp.:t. 59,2 (1909) non Kunth
F. umbellata Rottb.
Eleocharis dulcis (Burm.f.) Henschel
Fimbristylis complanata (Retz.) Link
F. ferruginea (L.) Vahl
F. obtusifolia (Lam.) Kunth
F. triflora (L.) K. Schum.
Bulbostylis contexta (Nees) Bodard
Cladium mariscus (L.) Pohl
 ? *Rhynchospora mauritii* Steud. (one very
 poor specimen)

ARECACEAE (Palmae)

Phoenix reclinata Jacq.

ARACEAE

Zamioculcas zamiifolia (Lodd.) Engl.
Gonatopus rhizomatosus Bogner & Oberm.
Stylochiton natalensis (Sond.) Schott

LEMNACEAE

Lemna perpusilla Torrey
Wolffipopsi welwitschii (Hegelm.) den Har-
 tog & van der Plas

XYRIDACEAE

Xyris anceps Lam.

COMMELINACEAE

Commelina diffusa Burm.f.
C. erecta L. subsp. *erecta*
C. erecta L. subsp.
C. forskalaei Vahl
Aneilema sp.
Coleotrype natalensis C.B.C1

JUNCACEAE

Juncus kraussii Hochst.

LILIACEAE

Gloriosa superba L.
Bulbine sp. ? *B. asphodeloides* (L.) Roem.
 & Schult. (inadequate material, fruits not
 seen)

Eriospermum sp. ? *E. luteo-rubrum* Bak.
 (inadequate material, basal parts not seen)
Aloe arborescens Mill.
A. bainesii Th. Dyer
A. parvibracteata Schonl.
Dipcadi viride (L.) Moench
Eucomis autumnalis (Mill.) Chitt. var.
clavata (Bak.) Reyneke ined.
E. pallidiflora Bak. var. *pole-evansii*
 (N.E.Br.) Reyneke ined.
Ornithogalum tenuifolium Delaroché
Drimiopsis maculata Lindl.
Ledebouria sp. cf. *L. apertiflora* (Bak.) Jes-
 sop
Asparagus africanus Lam.
A. densiflorus (Kunth) Jessop
A. falcatus L. var. *falcatus*
A. falcatus L. var. *ternifolius* (Bak.) Jessop
A. setaceus (Kunth) Jessop

AGAVACEAE

Sansevieria hyacinthoides (L.) Druce
S. sp.

SMILACACEAE

Smilax kraussiana Meisn.

AMARYLLIDACEAE

Scadoxus punicus (L.) Friis & Nordal
Crinum delagoense Verdoorn

HYPOXIDACEAE

Hypoxis spp.

DIOSCOREACEAE

Dioscorea crinita Hook.f.
D. sylvatica (Kunth) Eckl.

IRIDACEAE

Dietes vegeta (L.) N.E.Br.
Tritonia moggii Oberm.
Gladiolus dalenii van Geel
Anomatheca grandiflora Bak.
A. laxa (Thunb.) Goldblatt

ORCHIDACEAE

Bonatea pulchella Summerh.
B. speciosa (L.f.) Willd.
B. steudneri (Reichb. f.) Dur. & Schinz
Satyrium sphaerocarpum Lindl.
Vanilla roscheri Reichb.f.
 ? *Liparis* sp. (one very poor specimen)
Eulophia cucullata (Afzel. ex Swartz)
 Steud.

? *E. leachii* Greatrex ex Hall
E. petersii Reichb.f.
E. speciosa (R.Br. ex Lindl.) Bol.
Eulophidium tainioides (Schltr.) Summerh.
Solenangis aphylla (Thou.) Summerh.
Aërangis mystacidii (Reichb.f.) Schltr.
Cyrtorchis arcuata (Lindl.) Schltr. subsp.
 arcuata

DICOTYLEDONAE

ULMACEAE

Trema orientalis (L.) Blume
Chaetacme aristata E.Mey. ex Planch.

MORACEAE

Maclura africana (Bur.) Corner
Ficus capensis Thunb.
F. natalensis Hochst. sens. lat.
F. sansibarica Warb.
F. sycomorus L.
F. tremula Warb.
F. vogelii (Miq.) Miq.

URTICACEAE

Laportea peduncularis (Wedd.) Chew

LORANTHACEAE

Loranthus bolusii Sprague
L. dregei Eckl. & Zeyh.
L. sp.
Viscum tuberculatum A.Rich.

SANTALACEAE

Thesium sp.

OLACACEAE

Olax dissitiflora Oliv.
Ximenia caffra Sond.

POLYGONACEAE

Polygonum salicifolium Willd.
P. sp. cf. *P. pulchrum* Blume
Oxygonum delagoense Kuntze
Antigonon leptopus Hook. & Arn.

CHENOPODIACEAE

Chenopodium sp. (material very young)
Chenolea diffusa Thunb.
Arthrocnemum decumbens Toelken
A. natalense (Bunge ex Ung.-Sternb.) Moss
Salicornia pachystachya Bunge ex Ung.-Sternb.

AMARANTHACEAE

Amaranthus spinosus L.
A. thunbergii Moq.
Cyathula sp. ? near *C. spathulifolia* Lopr.
Pupalia lappacea (L.) A.L.Juss.
Psilotrichum africanum Oliv.
Achyranthes aspera L.

NYCTAGINACEAE

Boerhavia diffusa L. var. *diffusa*

AIZOACEAE

Limeum fenestratum (Fenzl) Heim.
L. viscosum (J. Gay) Fenzl subsp. *viscosum*
 var. *kraussii* Friedr.
Gisekia pharnaceoides L.
Glinus oppositifolius (L.) DC.
Sesuvium portulacastrum (L.) L.

MESEMBRYANTHEMACEAE

Carpobrotus dimidiatus (Haw.) L.Bol.

PORTULACACEAE

Portulacaria afra Jacq.
Portulaca quadrifida L.

CARYOPHYLLACEAE

Krauseola mosambicina (Moss) Pax &
 K.Hoffm.
Polycarpaea corymbosa (L.) Lam.

ILLECEBRACEAE

Pollichia campestris Ait.

NYMPHAEACEAE

Nymphaea capensis Thunb.

CERATOPHYLLACEAE

Ceratophyllum sp.

MENISPERMACEAE

Cissampelos hirta Klotzsch
Tiliacora funifera (Miers) Oliv.
Tinospora caffra (Miers) Troupin
Epinetrum delagoense (N.E.Br.) Diels

ANNONACEAE

Uvaria caffra E. Mey. ex Sond.
Monanthotaxis caffra (Sond.) Verdc.
Artabotrys monteiroae Oliv.
Annona senegalensis Pers.

LAURACEAE

Cassytha filiformis L.

BRASSICACEAE (Cruciferae)

Lepidium africanum (Burm.f.) DC. sens. lat.

CAPPARACEAE

Cleome angustifolia Forsk. subsp. *petersiana* (Klotzsch ex Sond.) Kers

C. macrophylla (Klotzsch) Briq.

C. monophylla L.

C. stricta (Klotzsch) R.A.Graham

Cladostemon kirkii (Oliv.) Pax & Gilg

Capparis brassii DC.

C. fascicularis DC. var. *fascicularis*

C. sepiaria L. var. *citrifolia* (Lam.) Toelken

C. tomentosa Lam.

Maerua angolensis DC.

M. nervosa (Hochst.) Oliv.

CRASSULACEAE

Kalanchoe paniculata Harv.

K. sp.

Crassula alba Forsk. var. *alba*

C. expansa Ait.

C. ovata (Mill.) Druce

BREXIIACEAE

Brexia madagascariensis (Lam.) Ker-Gawl.

LEGUMINOSAE

Albizia adianthifolia (Schumach.)

W.F.Wight

A. forbesii Benth.

A. versicolor Welw. ex Oliv.

Acacia karroo Hayne

A. kraussiana Meisn. ex Benth.

Dichrostachys cinerea (L.) Wight & Arn. subsp.

Elephantorrhiza elephantina (Burch.) Skeels

Entada schlechteri (Harms) Harms

Dialium schlechteri Harms

Cassia occidentalis L.

C. sp. nrst. C. quarrei (Ghesq.) Steyaert

Caesalpinia bonduc (L.) Roxb.

Cordyla africana Lour.

Sophora inhambanensis Klotzsch

Crotalaria capensis Jacq.

C. laburnoides Klotzsch

C. lanceolata E.Mey. subsp. *lanceolata*

C. monteiroi Taub. ex Bak.f.

C. pallida Ait. var. *pallida*

C. vasculosa Benth.

Indigofera charlieriana Schinz

I. inhambanensis Klotzsch

I. laxiracemosa Bak.f.

I. podophylla Benth. ex Harv.

I. spicata Forsk.

Tephrosia forbesii Bak. subsp. *inhacensis* Brummitt

T. longipes Meisn. subsp. *longipes* var. *icosisperma* Brummitt

T. lupinifolia DC.

T. purpurea (L.) Pers. subsp. *canescens* (E.Mey.) Brummitt var.

Sesbania sesban (L.) Merr. subsp. *sesban* var. *nubica* Chiov.

Aeschynomene micrantha DC.

A. sp.

Stylosanthes fruticosa (Retz.) Alston

Zornia capensis Pers.

Desmodium dregeanum Benth.

Alysicarpus vaginalis (L.) DC.

Dalbergia obovata E.Mey.

Derris trifoliata Lour.

Lathyrus sp. ? L. sativus L.

Abrus precatorius L. subsp. *africanus* Verdc.

A. sp.

Erythrina caffra Thunb.

Canavalia sp. ? C. rosea (Swartz) DC.

Cajanus cajan (L.) Millsp.

Rhynchosia caribaea (Jacq.) DC.

R. minima (L.) DC.

R. totta (Thunb.) DC.

Eriosema parviflorum E.Mey.

E. psoraleoides (Lam.) G. Don

Vigna spp.

Dolichos spp. These difficult genera need further study in depth.

Decorsea schlechteri (Harms) Verdc.

Macrotyloma axillare (E.Mey.) Verdc.

Lablab purpureus (L.) Sweet subsp. *uncinatus* Verdc.

GERANIACEAE

Pelargonium grossularioides (L.) Ait.

OXALIDACEAE

Oxalis semiloba Sond.

ERYTHROXYLACEAE

Erythroxylum emarginatum Thonn.

ZYGOPHYLLACEAE

Tribulus terrestris L.

BALANITACEAE

Balanites maughamii Sprague

RUTACEAE

Fagara schlechteri Engl.

Vepris undulata (Thunb.) Verdoorn & C.A.Sm.

Clausena anisata (Willd.) Hook.f. ex Benth.

BURSERACEAE

Commiphora neglecta Verdoorn

C. schlechteri Engl.

MELIACEAE

Xylocarpus granatum Koen

Melia azedarach L. Introduced

Trichilia emetica Vahl

MALPIGHIACEAE

Acridocarpus natalitius Adr. Juss. var. *natalitius*

POLYGALACEAE

Polygala capillaris E.Mey. ex Harv.

P. producta N.E.Br.

P. uncinata E.Mey. ex Meisn.

EUPHORBIACEAE

? *Heywoodia lucens* Sim (insufficient material)

Phyllanthus delagoensis Hutch. sensu PRE (some plants have 5 stamens + free filaments)

P. reticulatus Poir.

Drypetes natalensis (Harv.) Hutch.

Hymenocardia ulmoides Oliv.

Antidesma venosum E.Mey. ex Tul.

Cleistanthus schlechteri (Pax) Hutch.

Bridelia cathartica Bertol. f.

Croton pseudopulchellus Pax

Acalypha sp. ? *A. petiolaris* Hochst.

Tragia okanyua Pax

T. sp.

Dalechampia sp.

Ricinus communis L.

Suregada zanzibariensis Baill.

Sapium integerrimum (Hochst.) J.Leon.

Euphorbia heterophylla L.

E. hirta L.

E. tirucalli L.

E. triangularis Desf.

Synadenium sp.

Monadenium lugardae N.E.Br.

ANACARDIACEAE

Sclerocarya caffra Sond.

Lannea stuhlmannii (Engl.) Engl. var. *stuhlmannii*

Ozoroa obovata (Oliv.) R. & A. Fernandes var. *obovata*

Rhus microcarpa Schonl.

R. natalensis Bernh. ex Krauss

CELASTRACEAE

Maytenus procumbens (L.f.) Loes.

M. undata (Thunb.) Blakelock

Mystroxydon aethiopicum (Thunb.) Loes.

The name *Cassine aethiopica* Thunb. is upheld for this sp. in Pretoria

Hippocratea sp. ? *H. delagoensis* Loes.

Salacia kraussii (Harv.) Harv.

ICACINACEAE

Apodytes dimidiata E.Mey. ex Arn. subsp. *dimidiata*

SAPINDACEAE

Allophyllus natalensis (Sond.) de Wint.

Deinbollia oblongifolia (E.Mey.) Radlk.

Dodonaea viscosa Jacq.

RHAMNACEAE

Scutia myrtina (Burm.f.) Kurz

Colubrina asiatica (L.) Brongn.

VITACEAE

Rhoicissus revoilii Planch.

Cissus integrifolia (Bak.) Planch.

C. quadrangularis L.

C. sp.

Cyphostemma sp.

TILIACEAE

Corchorus trilocularis L.

Grewia caffra Meisn.

G. occidentalis L.

Triumfetta pilosa Roth. var. *effusa* (E.Mey.)

ex Harv.) Wild

T. rhomboidea Jacq.

MALVACEAE

Abutilon grantii Meeuse

Sida acuta Burm. f.

S. cordifolia L.

Pavonia leptocalyx (Sond.) Ulbr.

P. procumbens (Wight & Arn.) Walp.

Hibiscus cannabinus L.

H. diversifolius Jacq. subsp. *rivularis*
(Bremek. & Oberm.) Exell

H. schinzii Guerke.

H. surattensis L.

H. tiliaceus L.

H. trionum L.

Thespesia acutiloba (Bak.f.) Exell & Mendonca.

Gossypium herbaceum L. var. *africanum*
(Watt) Hutch. & Ghose

STERCULIACEAE

Melhantha forbesii Planch. ex Mast. (or possibly ? *M. acuminata* Mast. x *M. forbesii* Planch. ex Mast. vide Wild in Fl. Zam. 1 (2): 533 (1961))

Hermannia micropetala Harv.

Waltheria indica L.

OCHNACEAE

Ochna barbosae N. Robson

O. natalitia (Meisn.) Walp.

CLUSIACEAE (Guttiferae)

Garcinia livingstonei T. Anders.

FLACOURTIACEAE

Xylothea kraussiana Hochst.

Scolopia zeyheri (Nees) Harv.

Dovyalis longispina (Harv.) Warb.

Casearia gladiiformis Mast.

PASSIFLORACEAE

Adenia digitata (Harv.) Engl.

A. gummifera (Harv.) Harms

CACTACEAE

Opuntia sp. Introduced

THYMELAEACEAE

Gnidia denudata Lindl.

Synaptolepis kirkii Oliv.

LYTHRACEAE

Ammannia sp. ? *A. baccifera* L.

Galpinia transvaalica N.E.Br.

LECYTHIDACEAE

Barringtonia racemosa (L.) Spreng.

RHIZOPHORACEAE

Ceriops tagal (Perr.) C.B. Robinson

Rhizophora mucronata Lam.

Bruguiera gymnorrhiza (L.) Lam.

COMBRETACEAE

Pteleopsis myrtifolia (Laws.) Engl. & Diels

Terminalia sericea Burch. ex DC.

Lumnitzera racemosa Willd.

MYRTACEAE

Psidium guajava L. Escaped from cultivation

Eugenia sp.

Syzygium cordatum Hochst.

A few *Eucalyptus* spp. are cultivated

ONAGRACEAE

Ludwigia leptocarpa (Nutt.) Hara

Oenothera sp. ? *O. stricta* Ledeb.

HALORAGACEAE

Myriophyllum spicatum L.

ARALIACEAE

Cussonia arenicola Strey

APIACEAE (Umbelliferae)

Hydrocotyle bonariensis Lam.

Centella asiatica (L.) Urban

Pimpinella caffra (Eckl. & Zeyh.) D. Dietr.

PLUMBAGINACEAE

Plumbago zeylanica L.

SAPOTACEAE

Sideroxylon inerme L.

Mimusops caffra E. Mey. ex DC.

Manilkara concolor (Harv. ex C.H.Wr.)

Gerstner

M. discolor (Sond.) J.H. Hemsl.

EBENACEAE

Euclea natalensis DC.

E. schimperi (DC.) Dandy var. *daphnoides* (Hiern) de Wint.

E. undulata Thunb.

Diospyros inhacaensis F. White

D. rotundifolia Hiern

OLEACEAE

Olea africana Mill.

SALVADORACEAE

Azima tetracantha Lam.

LOGANIACEAE

Strychnos henningsii Gilg

S. madagascariensis Poir.

S. spinosa Lam.

GENTIANACEAE

Sebaea sp.? *S. longicaulis* Schinz (flowers rather old)

APOCYNACEAE

Carissa bispinosa (L.) Desf. ex Brenan var. *bispinosa*

C. macrocarpa (Eckl.) DC.

Landolphia kirkii R.A.Dyer

L. petersiana (Klotzsch) R.A.Dyer

Catharanthus roseus (L.) G.Don

Tabernaemontana elegans Stapf

PERIPLOCEAE

Cryptolepis obtusa N.E.Br.

ASCLEPIADACEAE

Asclepias fruticosa L.

A. physocarpa (E.Mey.) Schltr.

Cynanchum ellipticum (Harv.) R.A.Dyer

C. tetrapterum (Turcz.) R.A.Dyer

C. sp.

Sarcostemma viminale (L.) R.Br.

Secamone filiformis (L.f.) J.H.Ross

Ceropegia sp. cf. *C. sandersonii* Decne. ex Hook.f.

Tylophora sp.

CONVOLVULACEAE

Jacquemontia tamnifolia (L.) Griseb.

Hewittia sublobata (L.f.) Kuntze

Merremia tridentata (L.) Hall.f. subsp. *angustifolia* (Jacq.) van Ooststr.

Ipomoea albivenia (Lindl.) Sweet

I. ficifolia Lindl.

I. magnusiana Schinz

I. mauritiana Jacq.

I. pes-caprae (L.) R.Br. subsp. *brasiliensis* (L.) van Ooststr.

I. pes-tigridis L.

BORAGINACEAE

Ehretia petiolaris Lam.

? *Tournefortia* sp.

Heliotropium subulatum (Hochst. ex DC.) Vatke

VERBENACEAE

Verbena bonariensis L.

Lantana rugosa Thunb.

Lippia javanica (Burm.f.) Spreng.

Phyla nodiflora (L.) Greene

Priva sp.

Vitex amboniensis Guerke

Avicennia marina (Forsk.) Vierh.

LAMIACEAE (Labiatae)

Plectranthus amboinicus (Lour.) Spreng.

P. verticillatus (L.f.) Druce

Ocimum basilicum L.

SOLANACEAE

Lycium sp. cf. *L. oxycladum* Miers

L. sp.

Solanum goetzii Damm.

S. panduraeforme E.Mey.

S. sodomaeum L.

S. sp.

SCROPHULARIACEAE

Zaluzianskya sp. cf. *Z. lychnidea* Walp.

Torenia thouarsii (Cham. & Schlechtid.) Kuntze

Veronica anagallis-aquatica L.

Alectra sessiliflora (Vahl) Kuntze

A. vogelii Benth.

A. sp.

Sopubia cana Harv.

Buchnera sp. aff. *B. glabrata* Benth.

Striga asiatica (L.) Kuntze

S. gesnerioides (Willd.) Vatke ex Engl.

S. sp. cf. *S. junodii* Schinz

S. sp.

BIGNONIACEAE

Tecomaria capensis (Thunb.) Spach

PEDALIACEAE

Sesamum alatum Thonn.

Dicerocaryum senecioides (Klotzsch) Abels

LENTIBULARIACEAE

Utricularia inflexa Forsk. var. *stellaris* (L.f.) P.Tayl.

ACANTHACEAE

Thunbergia sp. ? *T. dregeana* Nees

Phaulopsis imbricata (Forsk.) Sweet

Barleria delagoensis Oberm.

B. gueinzii Sond.

Sclerochiton sp.

Blepharis maderaspatensis (L.) Roth.

Asystasia gangetica (L.) T.Anders.

RUBIACEAE

- Kohautia longifolia* Klotzsch
K. virgata (Willd.) Bremek.
Agathisanthemum bojeri Klotzsch
Pentodon pentandrus (Schumach. & Thonn.) Vatke var. *minor* Bremek.
Oldenlandia affinis (Roem. & Schult.) DC.
O. sp. possibly *O. goreensis* (DC.) Summerh.
Tarenna barbertonensis (Bremek.) Bremek.
T. junodii (Schinz) Bremek.
Enterospermum littorale Hiern.
Xeromphis obovata (Hochst.) Keay
X. rudis (E.Mey. ex Harv.) Codd
Gardenia sp.
Tricalysia capensis (Meisn.) Sim
T. sonderana Hiern
Kraussia floribunda Harv.
Vangueria infausta Burch.
Lagynias lasiantha (Sond.) Bull.
Canthium locuples (K.Schum.) Codd
C. obovatum Klotzsch
C. setiflorum Hiern
C. spinosum (Klotzsch) Kuntze
C. ventosum (L.) S.Moore
Plectroniella armata (K.Schum.) Robyns
Pavetta revoluta Hochst.
P. sp.
Psychoiria capensis (Eckl.) Vatke
Hydrophyllax carnosa Sond.
Spermacoce sp.

CUCURBITACEAE

- ? *Zehneria parvifolia* (Cogn.) J.H.Ross
Momordica balsamina L.
Citrullus lanatus (Thunb.) Matsumura & Nakai
Diplocyclos tenuis (Klotzsch) C.Jeffrey
Coccinea rehmannii Cogn.

CAMPANULACEAE

(NOTE: research is being done on this family at present)

- ? *Wahlenbergia androsacea* DC.
W. undulata DC.

LOBELIACEAE (sometimes included in Campanulaceae)

- Lobelia sp.* ? *L. senegalensis* DC.

GOODENIACEAE

- Scaevola thunbergii* Eckl. & Zeyh.

ASTERACEAE (Compositae)

- Ethulia conyzoides* L.
Vernonia aurantiaca (O.Hoffm.) N.E.Br.
V. centaurioides Klatt
V. sp.
Nidorella resedifolia DC.
N. sp.
Conyza canadensis (L.) Cronq.
C. ulmifolia (Burn.f.) Kuntze
Chrysocoma tenuifolia Berg.
Brachylaena discolor DC. subsp. *discolor*
Blumea cafra (DC.) O.Hoffm.
B. mollis (D.Don) Merr.
Gnaphalium pensylvanicum Willd.
G. septentrionale (Vatke) Hilliard
G. undulatum L.
Helichrysum argyrosphaerum DC.
H. candolleianum Buck.
H. decorum DC.
H. kraussii Sch. Bip.
H. longifolium DC.
H. stenopterum DC.
H. sp. aff. H. setosum Harv.
Acanthospermum hispidum DC.
Parthenium hysterophorus L.
Eclipta prostrata (L.) L.
Helianthus a gophyllus Torrey & Gray
Melanthera biflora (L.) Wild
M. scandens (Schumach. & Thonn.) Roberty subsp. *dregei* (DC.) Wild
Bidens biternata (Lour.) Merr. & Sherff
B. pilosa L.
Crassocephalum bojeri (DC.) Robyns
Cineraria pinnata O.Hoffm.
C. sp.
Senecio barbertonicus Klatt
S. deltoideus Less.
S. helminthioides (Sch.Bip.) Hilliard
S. madagascariensis Poir.
S. ngoyanus Hilliard
S. transvaalensis Bol.
Chrysanthemoides monilifera (L.) T.Norl. subsp. *rotundata* (DC.) T.Norl.
Arctotheca populifolia (Berg.) T.Norl.
Gazania krebiana Less. subsp. *serrulata* (DC.) Roessler
G. rigens (L.) Gaertn. var. *uniflora* (L.f.) Roessler.
Launaea sarmentosa (Willd.) Sch.Bip. ex Kuntze
Sonchus gigas Boulos ex Humbert
S. oleraceus L.

THE MORPHOLOGY OF *ACACIA REDACTA* J. H. ROSS

P. J. ROBBERTSE AND IRMGARD VON TEICHMAN

(Department of Botany, University of Pretoria)

ABSTRACT

Acacia redacta J. H. Ross is a small, much-branched shrub which grows in the Richtersveld. Ross (1974) provisionally placed it in the genus *Acacia* as fresh flowers and seeds were not available to aid him in his decision.

In this investigation the pollen, seeds, seedling and the anatomy of the pod, seed, wood and pinnules were studied. According to these characters *A. redacta* does not fit in with either of the two subgenera of *Acacia* represented in South Africa, or with *A. albida* (= *Faidherbia albida* (Del.) A. Chev.). If this new information could be supported by a chromosome study it might become necessary to regard *A. redacta* J. H. Ross as a new monotypic genus.

UITTREKSEL

DIE MORFOLOGIE VAN *ACACIA REDACTA* J. H. ROSS

Acacia redacta J. H. Ross is 'n klein veel-vertakte struik wat in die Richtersveld groei. Ross (1974) het dit voorlopig in die genus *Acacia* geplaas omdat daar geen vars blomme of saad beskikbaar was om hom in sy besluit te help nie.

In hierdie ondersoek is die stuifmeel, saad, saailinge en die anatomie van die peul, saad, hout en blaartjie bestudeer. Hiervolgens pas die kenmerke van *A. redacta* nie in by of die twee subgenera in Suid-Afrika van *A. albida* (= *Faidherbia albida* (Del.) A. Chev.) nie. Sou hierdie nuwe gegewens bevestig word deur 'n chromosoomondersoek mag dit nodig blyk om *A. redacta* J. H. Ross as 'n nuwe monotipiese genus te beskou.

INTRODUCTION

Acacia redacta was described by Ross in *Bothalia* (Ross, 1974) using material collected by Leistner & Werger in the Richtersveld. No ripe seed or fresh flowers were collected and, because Ross could not examine this plant fully, he "provisionally" placed it in the genus *Acacia*.

On a collecting trip to the Richtersveld in September 1977, ripe seeds, pods, dead flowers, young twigs with developing inflorescences, wood and herbarium specimens of plants growing on the western slope of a mountain of the eastern side of Jenkinskop, 20 km north of Eksteenfontein (Stinkfontein) -2817 (Vioolsdrif): CB (*Robbertse 1168*) were collected. This material was studied in order to evaluate the taxonomic position of this very interesting plant.

MATERIAL AND METHODS

The material mentioned above was fixed and preserved in FAA. For the anatomical investigation, the FAA-preserved material was dehydrated in ethylene

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glycol monomethyl ether, ethanol, propanol and butanol, infiltrated with GMA and embedded according to Feder and O'Brien (1968). Our monomer mixture, however, consisted of 95 % (v/v) hydroxyethyl methacrylate (purified in our laboratory to eliminate the methacrylic acid), 5 % (v/v) polyethylene glycol 200 and 0.1 % (w/v) azobis-iso-butyronitrile. Sections, 2 μm thick were cut with glass knives on a MT-1 "Porter Blum" ultramicrotome. The sections were stained with periodic acid—Schiff's reagent (PAS), followed by toluidine blue in benzoate buffer, pH 4.4 (Feder and O'Brien, 1968). The blocking agent, DNPH however, was applied for 30 minutes.

RESULTS AND DISCUSSION

Description

Small, much-branched shrubs, 0.3–1 m high (Fig. 1A). Bark dark grey-brown, firm, peeling in small strips. Young branches grey-brown, densely pubescent, with numerous, purplish-brown glandular bodies, consisting of tanniniferous cells on short stalks. Stipules spinescent, slender, straight, those of well-developed euphylls about 155 mm long, pubescent. *Leaves* bipinnate with two pinnae (Fig. 1B); petiole slender without adaxial gland, 2–6 mm long; rachilla 5–10 mm long; mucro prominent, up to 4 mm long; pinnules 2–4 pairs but mostly 3 pairs per pinna, 2.5 \times 1.5–3 mm, oblique, oblong or elliptic, apex rounded or obtuse (Figs 1 and 4), densely appressed pubescent on both surfaces, with scattered reddish-brown glandular bodies. *Inflorescence* pseudocapitate, axillary; peduncles 4–10 mm long with sterile bract on upper half, appressed pubescent with scattered glandular bodies. *Flowers* mostly three per inflorescence (Fig. 4B), sessile in axil of claw-shaped bract. Calyx cupular, 1–1.5 mm long, pubescent. Corolla 4–6 mm long, pubescent. *Stamens*: filaments 12–15 mm long, shortly connate basally to form a short tube, anther without gland. *Pollen* in polyads of 7–10, mostly 8 cells (Figs 1B, 2C and D); polyads irregular ellipsoidal, 130 \times 110 μm ; peripheral monads 5–6, smooth, without furrows, 50 μm along the polar axis and 63 μm wide, with four distal pores; exine 1.8 μm thick, central monads (4), 2, 1 or absent, smaller than peripheral monads. *Ovary* shortly stipitate to almost sessile. *Pods* erect, cream with purple edges 26–40 mm long, linear, oblong, straight, acute apically, 1–2, seeded, puberulous with scattered glandular bodies, dehiscent, splitting from apex to base in two recurving valves. *Seed* compressed grey-brown with maroon speckles, flattened and pointed at hilar end, 7–9 mm long, 5–6 mm wide, rapheole horseshoe-shaped (Fig. 5), central 1.5–2.5 mm long and 2 mm wide, funicle swollen at the placental end, tapering towards the hilum.

Seedling (Fig. 1B)

The seedling belongs to group 8B (Robberste & van der Schijff, 1971). Germination is epigeal and a well-developed taproot (Fig. 1B–R) is formed without a collar at the transition of the root to hypocotyl (see Vassal, 1969). The

hypocotyl is 27–33 mm long, and the cotyledons $12,6 \times 12$ mm with petioles 1–1,7 mm long. One or two prominent stipular spines per cotyledon occur. The first internode is less than 1 mm long, and the first vegetative leaf pinnate with three pinna pairs and prominent stipules. The pinnae are oblique, elliptic or subrotund, 5 mm long and 3,5 mm wide, and the apex mostly apiculate or rounded. One basal pinna is often rudimentary. The second and all subsequent leaves are bipinnate with two pinnae, each with three to four pinna pairs. Leaves and stem are puberulous with reddish-brown glandular bodies concentrated at the bases of leaves, pinnae and pinnules.

Anatomy of the stem

The epidermal cells are tanniferous with thick, lignified outer tangential walls. The trichomes are unicellular, fibre-like cells, 100–130 μm long. The first cortical layer consists of enlarged, tanniferous cells, followed by 7–9 layers of thin-walled parenchymatous cells containing a pinkish cell sap. A continuous sclerenchymatous cylinder of 1–4 cell layers of primary phloem fibres is found in the young stems. In older stems the cylinder is discontinuous due to secondary growth. A periderm originates from the subepidermal layer and the cortical cells continue dividing to keep pace with secondary growth. Strands of secondary phloem fibres are formed in the secondary phloem.

Wood anatomy

The wood is diffuse porous with pores in clusters in tangential groups. The tangential diameter of the pores is (24–) 38 (–75) μm . Axial xylem parenchyma is vasicentric paratracheal. Vessel elements are (60–) 81 (–90) μm long with gum deposits in vessels of the central wood. Intervascular pits are 5,6–7,5 μm in diameter, alternate and vested. Perforations are simple. Septate and gelatinous fibres are present. The rays are uni- to triseriate but mostly uniseriate.

Anatomy of the pod

In a cross section of the seedless parts, the pod is dumb-bell-shaped with the dorsal and ventral veins situated in the thickened ends. The inner epidermis and the first one or two subepidermal cell layers are tanniferous while the unicellular trichomes lack tannin. These cell layers are followed by two layers of relatively large parenchymatous cells which, after fixation in FAA contain a reticulate cytoplasm. This is followed by 6–8 layers of smaller parenchymatous cells, two to three layers of longitudinal fibres, one or two layers of transverse fibres and a thin-walled inner epidermis. The vascular bundles of the dorsal and ventral veins are capped with sclerenchymatous fibres.

Anatomy of the testa (Fig. 6A)

The description is based on a cross section through the middle (equator) of the seed.

The seed coat is 225–240 μm thick; the macrosclereids 31,9–33,5 μm long. The light line in the greater part of the testa is situated 7,5 μm from the cuticle but on both sides of the pleurogram it is 18,75 μm from the cuticle. Osteosclereids are flask-shaped, (38–) 45 (–56) μm long with a narrow neck. The mesotesta is 23–26 μm thick and consists of 5–7 layers of thick-walled, elongated cells with intercellular spaces and an inner layer with scattered, poorly-developed osteosclereids.

A uniserial endotesta of thin-walled elongated cells is appressed to a membrane consisting of the collapsed inner integument cells.

Anatomy of the leaf

As in all other South African *Acacia* spp., the nodes are trilacunar (Robbertse, 1975a). The three leaf traces unite in the leaf base to form a closed vascular cylinder which breaks up into a larger abaxial, a smaller adaxial and two lateral adaxial bundles.

The pinnule is amphistomatic (Fig. 6B) and the epidermis is tanniniferous with unicellular trichomes. The abaxial and adaxial palisade layers are separated by relatively large, colourless cells (Fig. 6B). This is a typical character of pinnules of the subgenus *Aculeiferum* (Vulgares, Robbertse, 1975a).

DISCUSSION

Concerning the taxonomy of *A. albida*, the following is noted briefly. Ross (1975) states that “*A. albida* displays a number of unusual characters, some of which are peculiar to this species alone amongst the African acacias”. “Chevalier in Rev. Bot. appl. Agric. trop. **14**: 876 (1934) considered the species to be sufficiently distinct from all others to transfer it to the monotypic genus *Faidherbia*.” Ross (1975), however, concludes that “in deciding whether or not the species should be excluded from *Acacia*, it depends upon whether the emphasis is placed on the differences or on the similarities. It may ultimately prove better to transfer the species to *Faidherbia*.”

The habit of *A. redacta* is different from all other South African *Acacia* spp. and is more or less similar to *Xerocladia viridiramis* (Burch.) Taub., also a mimosoid plant from the arid south western parts of the country (Ross, 1975). The plants grow on dry, rocky west-facing mountain slopes where they blend with other small shrubs of the succulent Karoo.

Acacia redacta differs from other South African *Acacia* spp. in having inflorescences containing mostly only three flowers (Fig. 4B). Ross (1975) described the inflorescence as “apparently capitate”. As can be seen in Fig. 4B

the fertile part of the inflorescence axis is reduced while a sterile bract appears on the upper half of the scape. This sterile bract can be regarded as a reduced cupule (involucl), which is a typical character of the subgenus *Acacia* (Gummiferae sensu Bentham) (Robbertse, 1974).

At the time when the material for this study was collected the dried flowers were still on the plants while young inflorescences in different ontogenetic stages were found in the axils of distal* leaves (Figs 3 and 4A). The young distal leaves and inflorescences develop simultaneously (Figs 3A & B) during the growing season which, in this winter rainfall area, can be from May to September. The best-developed flowers found already had well-differentiated microspore mother cells in the anthers (Fig. 2A). This early development of the flowers enables the plants to burst into flower immediately after the first autumn rains (\pm May).

No other South African *Acacia* spp. except *A. albida*, flowers in autumn (\pm May) to winter (Robbertse, 1974). The seeds of *A. albida* ripen towards the end of September and ripe seeds were also found on *A. redacta* during this collecting trip (see Introduction).

In Table 1 an evaluation of the outstanding characters of *A. redacta* is given in relation to typical characters of *A. albida*, and the subgenera *Acacia* and *Aculeiferum*. From the table it is clear that *A. redacta* can neither be regarded as a member of the subgenus *Acacia* nor the subgenus *Aculeiferum* since characters of both taxa are found in this species. It has more characters in common with *A. albida* but on the basis of the morphology of its inflorescence, pollen and seed, it is unique.

The polyads of *A. redacta* with 8 monads are $130\text{ }\mu\text{m} \times 110\text{ }\mu\text{m}$ in diameter while according to van Zinderen Bakker and Coetzee (1959) the polyads of *A. albida* with 16–30 monads is $98,4\text{ }\mu\text{m}$ and that of *A. giraffae* (= *A. erioloba*) $75\text{ }\mu\text{m}$. According to Guinet (1969) the polyads of all other *Acacia* spp. vary between $30\text{ }\mu\text{m} \times 20\text{ }\mu\text{m}$ to $61\text{ }\mu\text{m} \times 61\text{ }\mu\text{m}$ which is about the size of a single monad of *A. redacta*. The combination of the characters of a capitate inflorescence and flowers with connate stamens which is found in *A. redacta* is also unknown in the genus *Acacia*. The taxon *A. redacta* J. H. Ross is therefore probably not an *Acacia* spp. and should rather be regarded as a new, monotypic genus. A chromosome study will probably supply the crucial evidence for such a decision.

ACKNOWLEDGEMENTS

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*See Robbertse 1975a.

TABLE 1.
Evaluation of characters of *Acacia redacta*.

Characters for <i>A. redacta</i>	Character typical for		
	<i>A. albida</i>	Subgenus Acacia	Subgenus Aculeiferum
1. Stipular spines (Robbertse, 1975b) .	×	×	
2. Inflorescence capitate with involucre (Robbertse, 1974)		×	
3. Stamens connate at base (Robbertse, 1974)	×	—	—
4. Gland on anther absent (Robbertse, 1974)	×	—	—
5. Pollen grains without furrows (van Zinderen Bakker & Coetzee, 1959)	×		×
6. Ovary almost sessile (Robbertse, 1974)		×	
7. Glandular disc in flower absent (Robbertse, 1974)		×	
8. Transverse and longitudinal fibres in pod (Robbertse, 1975c)	×		×
9. Rays in wood uni- to triseriate (Robbertse, unpubl.)	×		×
10. Palisade in pinnule interrupted by spongy mesophyll (Robbertse, 1975a)	×		×
11. Collar at junction of root and hypocotyl absent			×
			some spp.
12. Position of light line in testa (Robbertse, 1973)		×	

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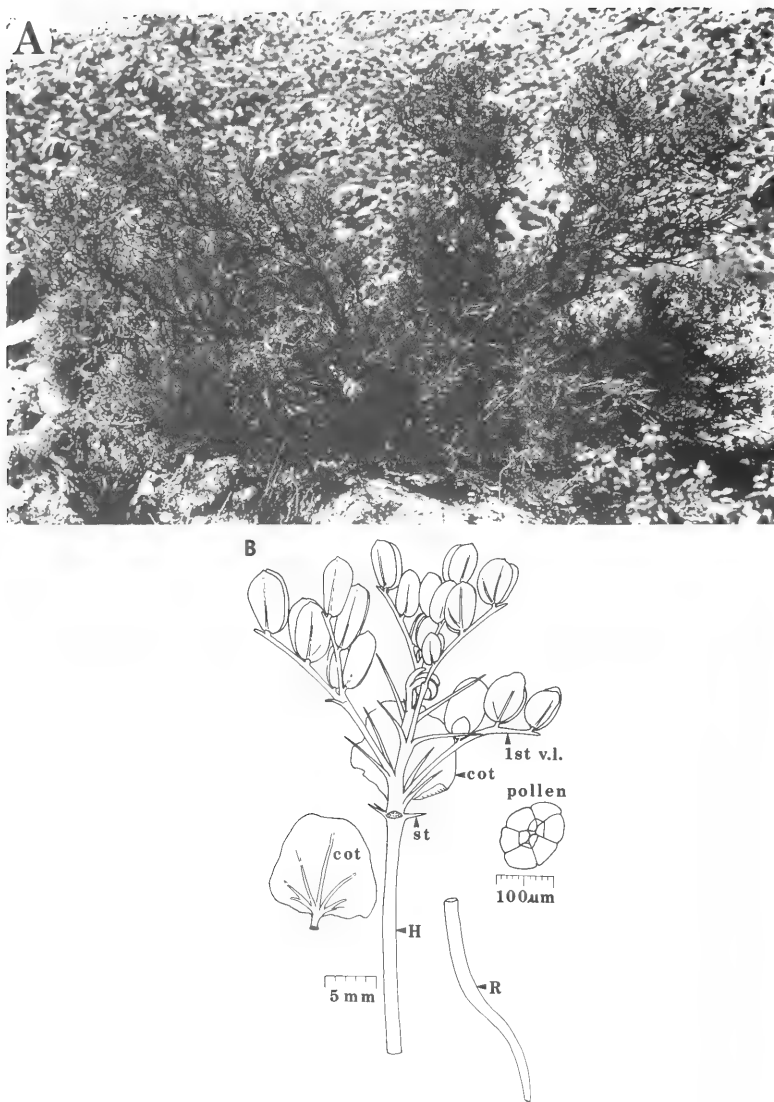


FIG. 1.

The habit of *A. redacta* (A) and the seedling (B) also showing a pollen polyad.
cot—cotyledon; *H*—hypocotyl; *R*—root; *st*—stipule; *1st v.l.*—first vegetative leaf.

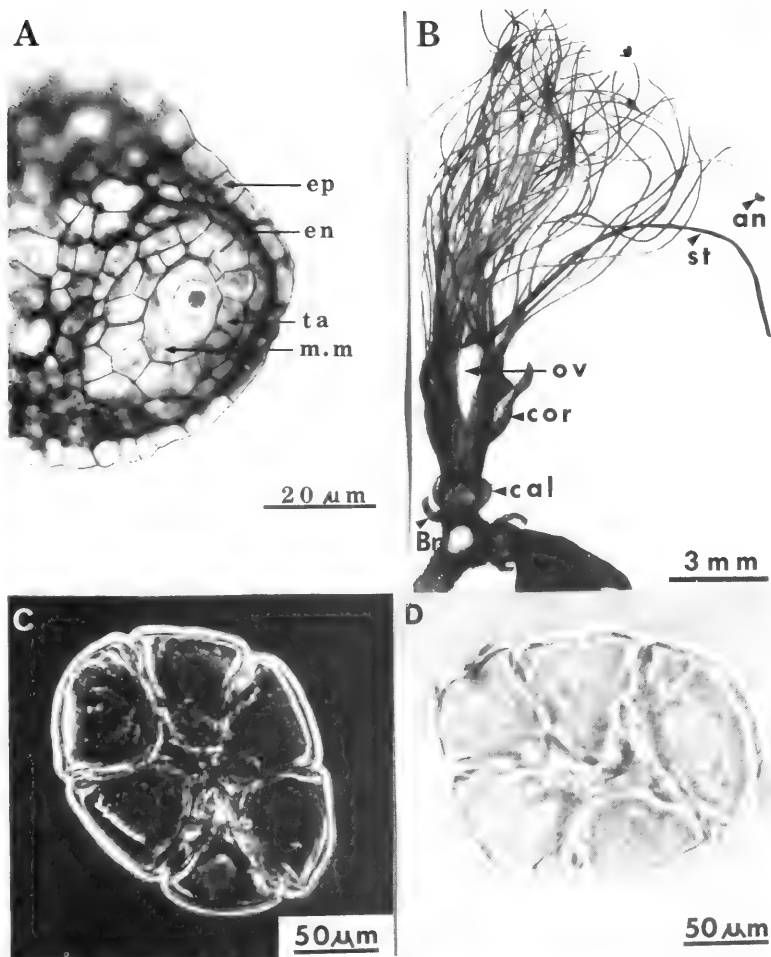


FIG. 2.

A cross section of an anther (A); B—a flower; C and D—pollen polyads. *an*—anther; *Br*—bract; *cal*—calyx; *cor*—corolla; *en*—endothecium; *ep*—epidermis; *m.m.*—microspore mother cell; *ov*—ovary; *st*—style; *ta*—tapetum.

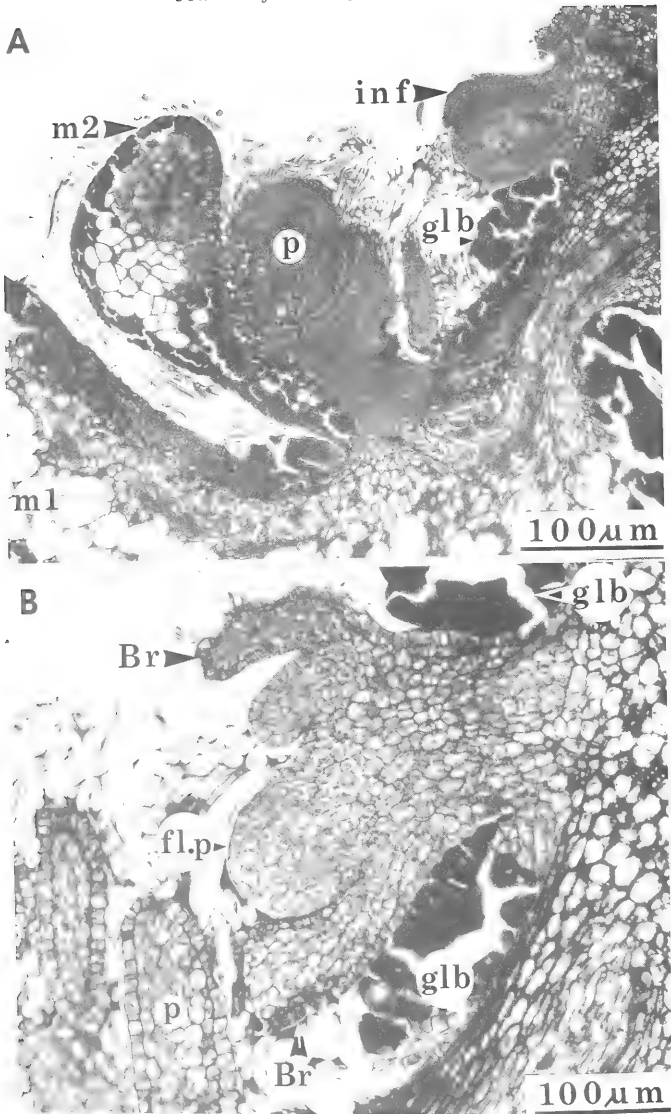


FIG. 3A and B.

Longitudinal sections of developing leaf and inflorescence. *Br*—bract; *fl.p*—floral primordium; *glb*—glandular bodies; *inf*—inflorescence; *m1*—mucro of rachis; *m2*—mucro of pinna; *p*—pinnule.

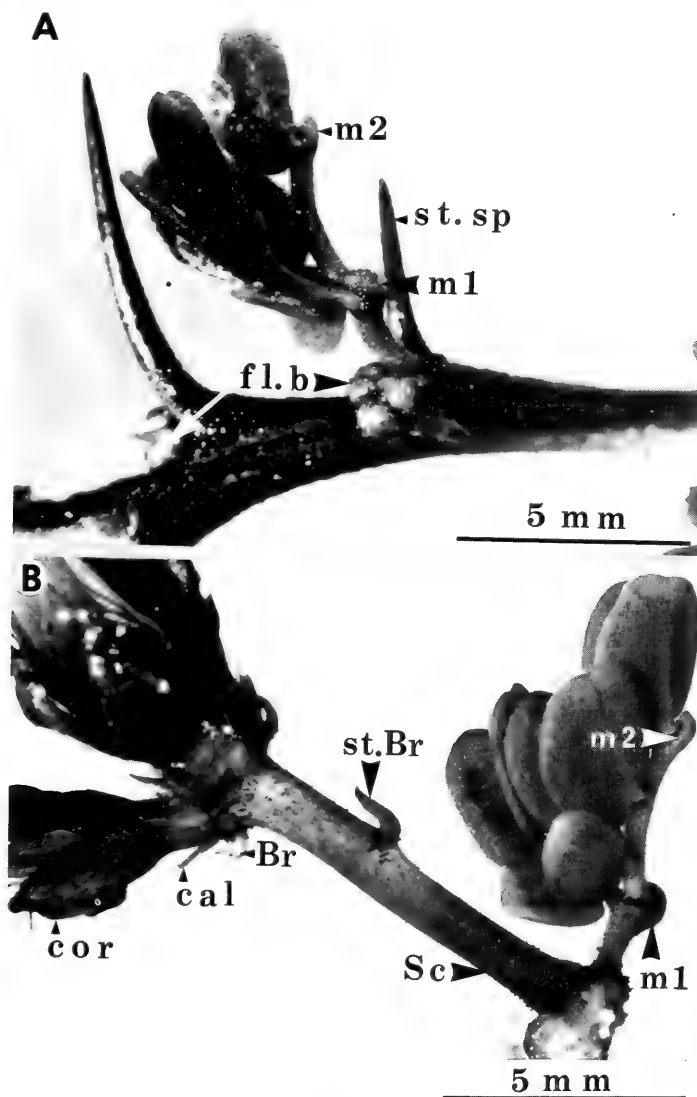


FIG. 4.

A twig with flower buds (A) and an inflorescence with subtending leaf (B). *Br*—bract; *cal*—calyx; *cor*—corolla; *fl.b*—flower buds; *m1*—mucro of rachis; *m2*—mucro of pinna; *Sc*—scape; *st.Br*—sterile bract; *st.sp*—stipular spine.

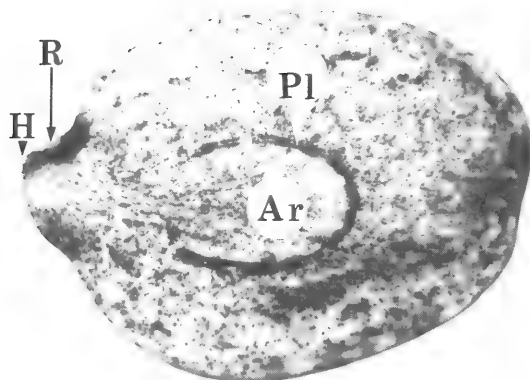
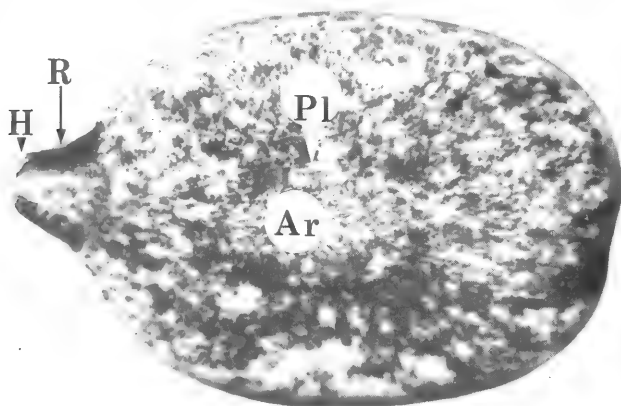
A**B**

FIG. 5A and B.
Different seeds of *A. redacta*. *Ar*—areole; *H*—hilum; *Pl*—pleurogram; *R*—rapheole.

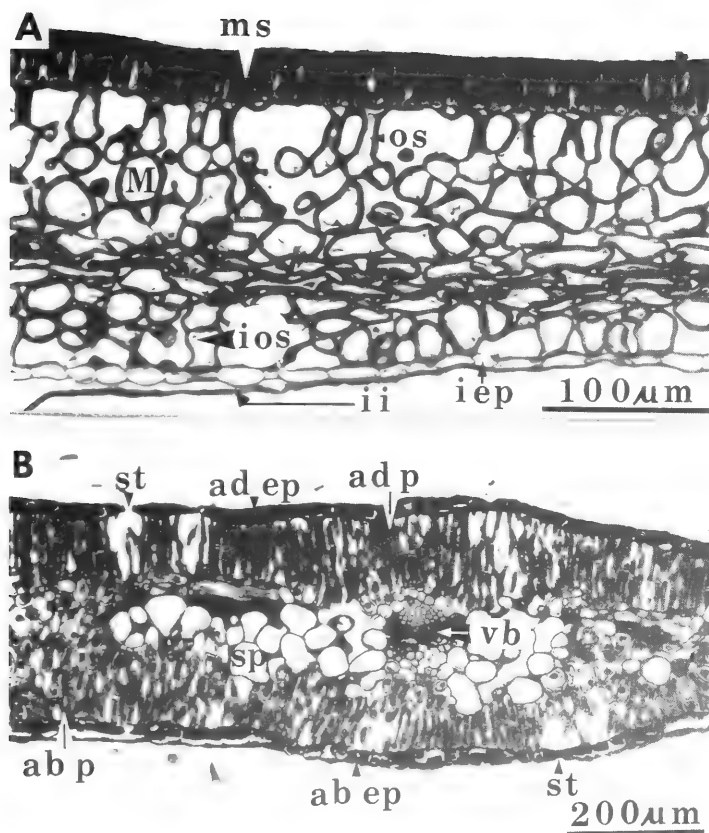


FIG. 6.

Cross sections of the testa (A) and a pinnule (B). *ab ep*—abaxial epidermis; *ab p*—abaxial palisade; *ad ep*—adaxial epidermis; *ad p*—adaxial palisade; *iep*—outer integument epidermis; *ii*—inner integument; *ios*—inner osteosclereids; *M*—mesophyll; *ms*—macrosclereids; *os*—osteosclereids; *sp*—spongy mesophyll; *st*—stomata; *vb*—vascular bundle.

A CHECK LIST OF FERNS AND FLOWERING PLANTS OF THE SUIKERBOSRAND NATURE RESERVE*

G. J. BREDEKAMP

(Department of Botany, University of the North)

A. v. W. LAMBRECHTS

(Nature Conservation Division, Transvaal Provincial Administration)

ABSTRACT

A systematic list of ferns and flowering plants of the Suikerbosrand Nature Reserve is given. The relationships between the numbers of families, genera and species of Pteridophyta, Monocotyledoneae and Dicotyledoneae are indicated. Families contributing more than 1% to the total number of species of the area, and genera containing more than four species are tabulated.

UITTREKSEL

'N KONTROLELYS VAN VARINGS EN BLOMPLANTE VAN DIE SUIKERBOS-RANDNATUURRESERVAAT

'n Sistematiese lys van varings en blomplante van die Suikerbosrandnatuurreseervaat word aangebied. Die verhoudings tussen die aantal families, genera en spesies van Pteridophyta, Monocotyledoneae en Dicotyledoneae word aangetoon. Families wat meer as 1% tot die totale aantal spesies van die gebied bydra, en genera wat meer as vier spesies bevat, word getabuleer.

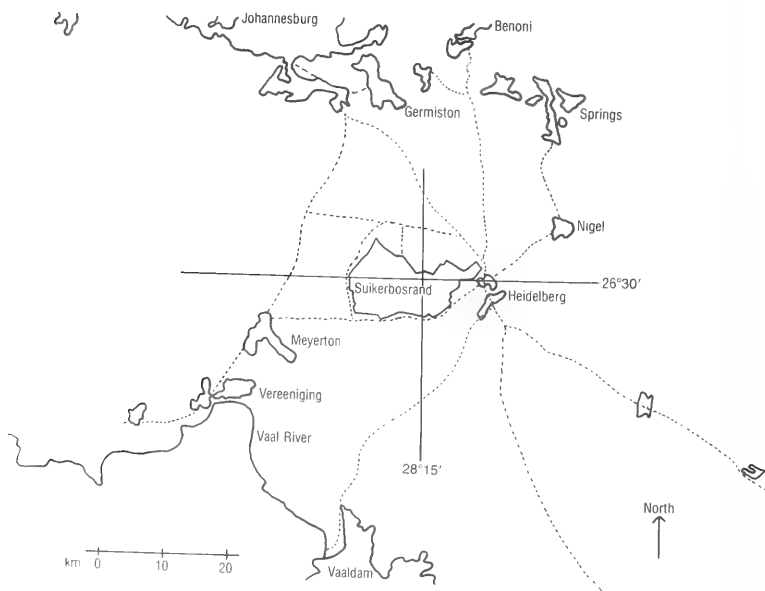
INTRODUCTION

The Suikerbosrand Nature Reserve is situated in the Bankenveld (Acocks, 1953), between S 26° 27' and 26° 34', and E 28° 09' and 28° 21', about 40 km south of Johannesburg (Fig. 1). The area was officially proclaimed as a Provincial Nature Reserve during March 1974 and, as very little floristic data were available, this survey was undertaken as part of two broader studies (Lambrechts, 1972 and Bredenkamp, 1975). The Reserve covers approximately 13 337 hectares. The altitude within the Reserve varies from 1 525 m to 1 916 m. The topography of the area is largely determined by its geology. Two geological formations are represented on the Reserve. The Witwatersrand System occupies the eastern part of the study area and the Ventersdorp System the western part. The Witwatersrand System is the older of the two formations and consists mainly of quartzite sediments which have undergone intensive folding, faulting and considerable erosion (Du Toit, 1954), thus resulting in the complex, broken topography of the

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area today. The hard quartzite rocks have eroded to a coarse sandy loam soil. A chain of very rocky hills, covered mostly with woody vegetation, and a relatively small, flat area of grassland are included in this System. Grassland is found at the foot of each rocky hill at an altitude of approximately 1 524 m to 1 600 m, as well as on a high altitude plateau, at an altitude of 1 700 m to 1 750 m.

The Ventersdorp System is mainly volcanic in origin and was deposited on top of the Witwatersrand System (Mountain, 1968). The lavas are mainly basaltic or andesitic in nature (Nel and Jansen, 1957) and weather to a sandy clay loam or clay loam soil. This System is represented by a chain of mountains and includes an undulating grassland plateau about 1 700 m to 1 916 m above sea level and a flat grassland situated at the foot of the mountains at an altitude of about 1 524 m to 1 600 m. The kloofs and mountain slopes are often covered with dense bush.



METHODS

Specimens were collected during the period 1970–1975. One set of specimens was sent to the Botanical Research Institute, Pretoria (PRE) for identification. Two sets of specimens collected by the senior author are housed in the Schweickerdt Herbarium, University of Pretoria, while an additional set of both authors is housed by the Nature Conservation Division of the Transvaal Provincial Adminis-

tration in a museum on the Reserve. Exotic trees and shrubs at the abandoned farm houses in the Reserve have been excluded.

RESULTS AND DISCUSSION

The flora is represented by 742 species. The relationship between the numbers of families, genera and species of the pteridophytes, monocotyledons and dicotyledons is given in Table 1.

TABLE 1.

The relationship between the numbers of families, genera and species of Pteridophyta, Monocotyledoneae and Dicotyledoneae of Suikerbosrand Nature Reserve.

	Pteridophyta		Monocotyledoneae		Dicotyledoneae		Total
	No.	% of total	No.	% of total	No.	% of total	
Families	6	6,52	12	13,04	74	80,43	92
Genera	10	2,58	102	26,35	275	71,05	387
Species	19	2,56	214	28,84	509	68,59	742

TABLE 2.

The numbers and percentages of species and genera of the families whose species comprise more than 1 % of the total number of species of Suikerbosrand Nature Reserve.

Family	No. of species	No. of Species expressed as a % of the total	No. of genera	No. of genera expressed as a % of the total
Gramineae	115	15,49	50	12,91
Compositae	110	14,82	47	12,14
Papilionaceae	52	7,00	22	5,68
Liliaceae	31	4,17	16	4,13
Cyperaceae	28	3,77	12	3,10
Scrophulariaceae	22	2,96	15	3,87
Asclepiadaceae	21	2,83	13	3,35
Rubiaceae	20	2,69	14	3,61
Acanthaceae	17	2,29	10	2,85
Labiatae	15	2,02	12	3,10
Anacardiaceae	13	1,75	1	0,25
Solanaceae	11	1,48	4	1,03
Iridaceae	11	1,48	8	2,06
Euphorbiaceae	11	1,48	4	1,03
Orchidaceae	11	1,48	5	1,29
Malvaceae	10	1,34	4	1,03
Crassulaceae	10	1,34	4	1,03
Convolvulaceae	10	1,34	4	1,03
Verbenaceae	10	1,34	6	1,55
Sterculiaceae	8	1,07	3	0,77
Cucurbitaceae	8	1,07	6	1,55
Campanulaceae	8	1,07	2	0,51

There are 22 families, that is 23.91 % of the total number of families, whose species contribute more than 1 % of the total number of species, and these are listed in order of numerical importance in Table 2. The number of genera present in these families are also given in Table 2.

The 25 genera with more than four species each, are listed in Table 3.

TABLE 3.
Synopsis of the genera with more than four species, in numerical order.

Genus	No. of species	Genus	No. of species
<i>Helichrysum</i>	20	<i>Berkheya</i>	7
<i>Senecio</i>	19	<i>Setaria</i>	6
<i>Eragrostis</i>	16	<i>Thesium</i>	6
<i>Rhus</i>	13	<i>Hermannia</i>	6
<i>Indigofera</i>	11	<i>Scirpus</i>	5
<i>Aristida</i>	10		
<i>Cyperus</i>	9	<i>Hypoxis</i>	5
<i>Solanum</i>	8	<i>Eulophia</i>	5
<i>Digitaria</i>	8	<i>Crassula</i>	5
<i>Asclepias</i>	8	<i>Rynchosia</i>	5
<i>Sporobolus</i>	7	<i>Polygala</i>	5
<i>Asparagus</i>	7	<i>Hibiscus</i>	5
<i>Vernonia</i>	7	<i>Ipomoea</i>	5

SYSTEMATIC LIST

Specimen collection numbers follow each taxon in the list. Collection numbers of the co-author are marked with the letter L.

In the systematic list the Pteridophyta are arranged according to Schelpe (1969) and Angiospermae excluding the Gramineae according to Phillips (1951). The Gramineae are arranged according to Hubbard (1934). No indigenous Gymnospermae occur in the Reserve. The species are arranged alphabetically within each genus.

PTERIDOPHYTA

SELAGINELLACEAE

Selaginella dregei (C. Presl) Hieron. L203, 870 Rocky outcrops, common.

OSMUNDACEAE

Osmunda regalis L. 215 Along shaded streams, uncommon.

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn var. L241, 216 Rocky quartzite hills, abundant.

POLYPODIACEAE

Pleopeltis macrocarpa (Bory ex Willd.) Kaulf. 707 Along shaded streams, uncommon.

ADIANTACEAE

- Cheilanthes eckloniana* (Kuntze) Mett. 22, 268 Rocky quartzite hills, abundant.
C. hirta Swartz 449, 1070 Rocky quartzite hills, abundant.
C. multifida (Swartz) Swartz L45, 874 Rocky hills, uncommon.
Dryopteris athamantica (Kuntze) Kuntze L292 Along shaded streams, rare.
D. inaequalis (Schlechtld.) Kuntze 889 Along shaded streams, rare.
D. thelypteris (L.) A. Gray L41 Along shaded streams, rare.
Pellaea calomelanos (Swartz) Link 423B, 1069 Rocky quartzite hills, abundant.
P. viridis (Forsk.) Prantl L220, 259, 424 Rocky quartzite hills, uncommon.
Pteris cretica L. 828 Along shaded streams, uncommon.
P. dentata Forsk. subsp. *fiabellata* (Thunb.) Runemark 652 Along shaded streams, uncommon.

ASPLENIACEAE

- Asplenium adiantum-nigrum* L. 979 Along shaded streams, uncommon.
A. aethiopicum (Burm.f.) Bech. 19 Along shaded streams, uncommon.
A. platyneuron (L.) Oakes 276 Along shaded streams, uncommon.
A. trichomanes L. 800 Along shaded streams, uncommon.
Ceterach cordatum (Thunb.) Desv. 861 Along shaded streams, uncommon.

SPERMATOPHYTA

ANGIOSPERMAE

MONOCOTYLEDONEAE

TYPHACEAE

- Typha latifolia* L. subsp. *capensis* Rohrb. 442 In small dams, locally abundant.

POACEAE (Gramineae)

- Urelytrum squarrosus* Hack. 640 Valley grassland, occasional.
Elionurus argenteus Nees L113, L339, 260, 271 Grassland, abundant.
Imperata cylindrica (L.) Beauv. 1036 Grassland, occasional.
Sorghum verticilliflorum (Steud.) Stapf 486, 695, 1012 Grassland, rare.
Schizachyrium sanguineum (Retz.) Alston L179, 661 Valley grassland, occasional.
S. ursulus Stapf 805 Valley grassland, rare.
Andropogon appendiculatus Nees L86A, 105, 900 Valley grassland, occasional.
A. eucomus Nees L250, 788 Marshy areas, rare.
A. schirensis Hochst. ex A. Rich. var. *angustifolia* Stapf L257, L270, 768, 769 Valley grassland, fairly abundant.
Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy L75, L143, L28, 1055 Plateau grassland, abundant.
C. marginatus (Steud.) Stapf ex Burtt Davy 408 Rocky quartzite hills, abundant.
C. validus (Stapf) Stapf ex Burtt Davy 468 Marshy areas, rare.
Hyparrhenia dregeana (Nees) Stapf ex Stent 563, 567, 744, 831 Marshy areas, rare.
H. filipendula (Hochst.) Stapf var. *pilosa* (Hack.) Stapf L79 Grassland, rare.
H. hirta (L.) Stapf L100, 109, 328, 1044 Grassland, abundant.
H. tamba (Hochst. ex Steud.) Anderss. ex Stapf 702 Grassland, rare.
Monocymbium ceresiiforme (Nees) Stapf L154, 660 Plateau grassland, abundant.
Trachypogon spicatus (L.f.) Kuntze L85, L144, 632, 659 Grassland, abundant.
Heteropogon contortus (L.) Beauv. ex Roem. & Schult. L92, L166, 245, 466 Grassland, abundant.
Diheteropogon amplexans (Nees) Clayton L86, L142, 631, 662 Grassland, fairly abundant.
D. filifolius (Nees) Clayton L61A, L77A, 348, 658 Valley grassland, fairly abundant.
Themeda triandra Forsk. L67, L272, 248, 787 Grassland, abundant.

- Digitaria argyrograptia* (Nees) Stapf 521, 724 Valley grassland, uncommon.
D. diagonalis (Nees) Stapf L258, L269, 704, 790 Plateau grassland, abundant.
D. eriantha Steud. 627, 646, 667 Grassland, common.
D. monodactyla (Nees) Stapf L49A, 467, 775, 865 Valley grassland, common.
D. pentzii Stent L100A Rocky hills, uncommon.
D. ternata (A.Rich.) Stapf L80, L132, 572, 789 Grassland, uncommon.
D. tricholaenoides Stapf L178, L416, 267, 641 Valley grassland, common.
D. zeyheri (Nees) Henr. L437 Grassland, rare.
Alloteropsis semialata (R.Br.) Hitchc. 853, 886 Grassland, rare.
Brachiaria boveoni (Chiov.) Robyns L39A Grassland, uncommon.
B. advena Vickery 556 Grassland, uncommon.
B. nigropedata (Munro ex Fical. & Hiern) Stapf 516 Grassland, uncommon.
B. serrata (Thunb.) Stapf L84, L87, 62, 249 Grassland, abundant.
Paspalum dilatatum Poir. L96, L295, 701, 849 Marshy area, locally abundant.
P. scrobiculatum L. L103A, 1002 Marshy area, locally abundant.
P. urvillei Steud. 406, 776 Marshy area, locally abundant.
Urochloa panicoides Beauv. L130 Grassland, uncommon.
Panicum deustum Thunb. 515 Kloof, uncommon.
P. laevifolium Hack. L298, L417, 693, 735 Amongst bush, uncommon.
P. maximum Jacq. 405, 823, 1020 Kloof, common.
P. natalense Hochst. L54A, 635 Valley grassland, abundant.
Setaria flabellata Stapf L70, L176, 244, 325 Grassland, common.
S. nigrirostris (Nees) Dur. & Schinz L268, L29A, 253, 476 Plateau grassland, abundant.
S. pallide-fusca (Schumach.) Stapf & C.E.Hubb. 496, 497, 570, 732 Disturbed areas, common.
S. perennis Hack. L20A, L95A, L423, 95 Disturbed areas, common.
S. sphacelata (Schumach.) Stapf & C.E.Hubb. 480 Marshy area, uncommon.
S. woodii Hack. 494 Marshy area, uncommon.
Rhynchelytrum repens (Willd.) C.E.Hubb. L161, 825 Grassland, common.
R. setifolium (Stapf) Chiov. L102, L88, 237 Rocky quartzite hills, abundant.
Tricholaena monachne (Trin.) Stapf & C.E.Hubb. L314 Bushveld area, uncommon.
Pennisetum sphacelatum (Nees) Dur. & Schinz L310 Grassland, rare.
P. thunbergii Kunth 326, 439, 571 Grassland, rare.
Leersia hexandra Swartz L293, L311, 411, 574 South-facing slopes, grassland, fairly common.
Ehrharta erecta Lam. 284, 407, 978 Kloof, uncommon.
Phalaris aquatica L. 568 Marshy area, rare.
Arundinella nepalensis Trin. L299, L307, 566, 573 Marshy area, uncommon.
Tristachya hispida (L.f.) K.Schum. L89, L158, 286, 600 Grassland, common.
T. rehmannii Hack. L313, 637, 774 Grassland, occasional.
Loudetia simplex (Nees) C.E.Hubb. L202, L208, 349, 558 Rocky areas, fairly abundant.
Helictotrichon turgidulum (Stapf) Schweick. L431, 327, 560, 909 Plateau grassland, fairly abundant.
Phragmites australis (Cav.) Trin. ex Steud. L242, 1077 Marshy area, locally abundant.
Agrostis continuata Stapf L300 Marshy area, uncommon.
A. lachnantha Nees 410, 493, 606 Marshy area, area locally abundant.
Aristida adscensionis L. L111, L164, 525, 717 Disturbed areas, occasional.
A. aequiglumis Hack. L199 Disturbed areas, occasional.
A. bipartita (Nees) Trin. & Rupr. L163, 492, 772 Grassland, uncommon.
A. canescens Henr. subsp. *canescens* L65 Grassland, uncommon.
A. congesta Roem. & Schult. subsp. *congesta* L64, 390, 734, 771 Disturbed areas, occasional.
A. dasydesmis (Pilg.) Mez 935, 984 Disturbed areas, occasional.
A. diffusa Trin. subsp. *burkei* (Stapf) Schweick. 628 Disturbed areas, occasional.
A. junciformis Trin. & Rupr. L51A, L120A, 392, 638 Disturbed areas, abundant.
A. scabrivalvis Hack. 1001 Disturbed areas, uncommon.

- Aristida transvaalensis* Henr. L249, L278, 555 Rocky areas, abundant.
Tragus berteronianus Schult. 730 Disturbed areas, uncommon.
Sporobolus africanus (Poir.) Robyns & Tournay L95, 737 Grassland, occasional.
S. centrifugus Nees L76A, L435 Grassland, occasional.
S. discosporus Nees 490 Grassland, uncommon.
S. fimbriatus Nees L98, L191, L436, 519 Grassland, uncommon.
S. pectinatus Hack. L362, L418, 561 Rocky areas, common.
S. pyramidalis Beauv. 630 Grassland, occasional.
S. stapfianus Gand. 517 Grassland, occasional.
Eragrostis atrovirens (Desf.) Trin. L248 Grassland, uncommon.
E. capensis (Thunb.) Trin. L83, L340, 111, 246 Grassland, common.
E. chloromelas Steud. 242 Grassland, common.
E. cilianensis (All.) Lutati L454, 472, 592 Grassland, occasional.
E. curvula (Schrud.) Nees L97, L74, 110, 239 Grassland, common.
E. gummiflua Nees L103, L195, L274, 668 Grassland, occasional.
E. heteromera Stapf 557 Grassland, occasional.
E. nindensis Fical. & Hiern L81, L168, L219, L276 Grassland, occasional.
E. obtusa Munro ex Fical. & Hiern L66 Grassland, occasional.
E. plana Nees L93A Grassland, occasional.
E. planiculmis Nees L301 Grassland, occasional.
E. pseudosclerantha Chiov. L192, 721, 969 Grassland, occasional.
E. racemosa (Thunb.) Steud. L46A, L70A, 235, 243 Grassland, abundant.
E. sclerantha Nees L215, L316, 794, 1068 Grassland, occasional.
E. stapfii De Wint. 810 Grassland, occasional.
E. tef (Zucc.) Trotter L388, 793 Grassland, occasional.
Microchloa caffra Nees L60A, 278, 518 Grassland, common.
Cynodon dactylon (L.) Pers. L123, 324 Disturbed areas, common.
C. hirsutus Stent 491 Disturbed areas, uncommon.
C. incompletus Nees L263 Disturbed areas, uncommon.
Harpochloa falx (L.f.) Kuntze L419, L421, 270, 505 South-facing slopes, grassland, fairly common.
Chloris virgata Swartz L255, 733, 786 Bushveld area, uncommon.
Eustachys mutica (L.) Cufod. L104, L393, 405A, 464 Rocky north-facing slopes, fairly common.
Eleusine indica (L.) Gaertn. subsp. *africana* (K.-O'Byrne) S. Phill. L259, 729 Disturbed areas, uncommon.
Pogonarthria squarrosa (Licht.) Pilg. L200, L337, 657, 666 Grassland, common.
Diplachne biflora Hack. ex Schinz L422, 636, 779, 1079 South-facing slopes, grassland, occasional.
Triraphis andropogonoides (Steud.) Phill. L285, 669, 778 Plateau grassland, occasional.
Trichoneura grandiglumis (Nees) Ekman L198, 639 Grassland, common.
Enneapogon scoparius Stapf L91, L184, 824 Plateau grassland, occasional.
Koeleria cristata (L.) Pers. L432, 258, 469 South-facing slopes, grassland, occasional.
Festuca scabra Vahl 295, 873, 892 South-facing slopes, grassland, occasional.
Bromus leptoclados Nees 285 Kloof, occasional.

CYPERACEAE

- Cyperus albostratus* Schrad. 346, 1074, 1075 Grassland, occasional.
C. esculentus L. 903 Disturbed area, uncommon.
C. haspan L. 479 Marshy area, uncommon.
C. longus L. 569 Marshy area, uncommon.
C. margaritaceus Vahl 238 Grassland, occasional.
C. marginatus Thunb. 565 Grassland, occasional.
C. obtusiflorus Vahl var. *obtusiflorus* L153, 61, 1045 Grassland, occasional.
C. obtusiflorus Vahl var. *flavissimus* Boeck. 323 Grassland, occasional.

- Cyperus rupestris* Kunth L58A, 241, 890 Grassland, common.
Pycnus macranthus C.B.Cl. 321, 435 Marshy area, uncommon.
Mariscus capensis (Steud.) Schrad. 343, 610 Marshy area, uncommon.
M. congestus C.B.Cl. 593 Marshy area, uncommon.
Kyllinga erecta K. Schum. L237, 562 Grassland, occasional.
Scirpus burkei C.B.Cl. 923 Grassland, occasional.
S. cernuus Vahl 589 In water, uncommon.
S. diabolicus Steud. 587, 607, 611 In water, uncommon.
S. fluitans L. L294 In water, uncommon.
S. lacustris L. 320, 452 In water, uncommon.
Schoenoplectus paludicola (Kunth) Palla ex J. Raynal 609 In water, uncommon.
Fimbristylis complanata (Retz.) Link 586 In water, uncommon.
Abildgaardia ovata (Burm.f.) Kral 605 Grassland, east-facing slope, rare.
Bulbostylis burchelli (Fical. & Hiern) C.B.Cl. L180, L207, 301, 333 Grassland, occasional.
B. oritrephes (Ridley) C.B.Cl. 108 Grassland, occasional.
Epischoenus adnatus Levyns L297 Grassland, occasional.
Kobresia kunthiana (Kueenth.) Koyama 917 Grassland, occasional.
K. sparteum (Wahlb.) Koyama 653 Grassland, occasional.
Carex cernua Boott. 354 Along streambank, occasional.
C. spicata-paniculata C.B.Cl. 287 Grassland, occasional.

ARACEAE

- Zantedeschia aethiopica* (L.) Spreng. 575 Vlei area, rare.

COMMELINACEAE

- Commelina africana* L. 477, 489 Kloof, occasional.
C. eckloniana Kunth L69 Kloof, occasional.
C. erecta L. 478 Kloof, occasional.
Cyanotis foecunda Hassk. L280 Grassland, uncommon.
C. speciosa (L.f.) Hassk. 69, 377, 803 Grassland, uncommon.

JUNCACEAE

- Juncus exsertus* Bunchen 420, 608 In water, uncommon.

LILIACEAE

- Androcymbium melanthioides* Willd. forma *striatum* Hochst. 446 Plateau grassland, rocky areas, occasional.
Bulbine abyssinica A.Rich. 24 Grassland, occasional.
B. narcissifolia Salm-Dyck 1014 Thornveld, clay soils, rare.
B. trichophylla Bak. 252 Grassland, occasional.
Anthericum cf. *A. angulicaule* Bak. L430 Grassland, occasional.
A. fasciculatum Bak. 139, 260 Grassland, occasional.
Trachyandra saltii (Bak.) Oberm. L118, L354, 68 Grassland, rare.
Chlorophytum bowkeri Bak. L188, 655 Kloof, uncommon.
Bowiea volubilis Harv. ex Hook.f. 1034 Grassland, east-facing slope, rare.
Kniphofia porphyrantha Bak. 576 Marshy area, rare.
Aloe davyana Schonl. 578A Mountain slopes, abundant.
A. marlothii Berger 578B Rocky north-facing slopes, Ventersdorp System, common.
A. verecunda Pole Evans 578C Rocky quartzite hills, south-facing slopes, occasional.
Agapanthus campanulatus Leighton subsp. *patens* (Leighton) Leighton 578 Rocky south-facing slopes, rare.
Albuca setosa Jacq. L175, 26, 74 Grassland, occasional.
A. trichophylla Bak. 514, 1073 Grassland, occasional.
Dipcadi viride (L.) Moench 251 Grassland, occasional.

- Litanthus pusillus* Harv. 454 Plateau grassland, rare.
Scilla nervosa (Burch.) Jessop 642 Plateau grassland, uncommon.
Ledebouria cooperi (Hook.f.) Jessop 296 Plateau grassland, uncommon.
L. marginata (Bak.) Jessop 27, 847 Plateau grassland, common.
L. ovatifolia (Bak.) Jessop 974 Plateau grassland, uncommon.
L. undulata (Jacq.) Jessop 1000 Plateau grassland, uncommon.
Eucomis autumnalis (Mill.) Chitt. var. *clavata* (Bak.) Reyneke 507, 613 Grassland, uncommon.
Asparagus aethiopicus L. var. *angusticladus* Jessop 15 Dense bush, south-facing slopes, uncommon.
A. africanus Lam. L231, 848 Thornveld, occasional.
A. asparagoides (L.) Wight 968 Dense bush along streambanks, uncommon.
A. larinicus Burch. 1027B Bushy area, uncommon.
A. setaceus (Kunth) Jessop 461 Bushy area, uncommon.
A. suaveolens Burch. L233, 217, 970 Thornveld, abundant.
A. virgatus Bak. 656 Bushy area, uncommon.

AMARYLLIDACEAE

- Haemanthus hirsutus* Bak. L363, 506 Rocky quartzite hills, uncommon.
Boophane disticha (L.F.) Herb. 25A Grassland, occasional.
Crinum graminicola Verdoorn 25B Grassland, occasional.
Cyrtanthus tuckii Bak. 25 Plateau grassland, rare.

HYPOXIDACEAE

- Hypoxis argentea* Harv. ex Bak. 76 Grassland, rare.
H. galpinii Bak. 289, 926 Grassland, uncommon.
H. multiceps Buchinger 1041 Grassland, uncommon.
H. rigidula Bak. 106 Grassland, occasional.
H. rooperi S. Moore L181, 75, 98 Grassland, occasional.

DIOSCOREACEAE

- Dioscorea retusa* Mast. 782 Kloof, uncommon.
D. vietatica (Kunth) Eckl. L186, 484 Rocky quartzite hills, north-facing slopes, abundant.

IRIDACEAE

- Moraea stricta* Bak. 78 Grassland, uncommon.
Homeria pallida Bak. 32 Grassland, uncommon.
Aristea woodii N.E.Br. 451 Grassland, uncommon.
Dierama cf. *D. medium* N.E.Br. 623 South-facing slopes, rare.
Tritonia nelsonii Bak. 282, 336, 441 Rocky areas, plateau, occasional.
Crocasmia paniculata (Klatt) Goldbl. 1081 Grassland, uncommon.
Babiana hypogaea Burch. L82A, 687 Grassland, uncommon.
Gladiolus crassifolius Bak. L54, 679 Grassland, uncommon.
G. longicollis Bak. var. *platypetalus* (Bak.) Oberm. 199 Grassland, uncommon.
G. permeabilis Delaroche subsp. *edulis* (Burch. ex Ker-Gawl.) Oberm. L217 Grassland, uncommon.
G. sericeo-villosus Hook.f. 612 Grassland, uncommon.

ORCHIDACEAE

- Habenaria barbertonii* Kraenzl. & Schltr. 686 Plateau grassland, rare.
H. ciliosa Lindl. 788 Plateau grassland, rare.
Bonatea cf. *B. antennifera* Rolfe 1016 Thornveld, uncommon.
Brownleea parviflora Harv. ex Lindl. 783 Plateau grassland, rare.

- Disa aconitoides* Sond. 629 Plateau grassland, rare.
Eulophia clavicornis Lindl. var. *inaequalis* (Schltr.) Hall 159 Plateau grassland, uncommon.
E. clavicornis Lindl. var. *nutans* (Sond.) Hall 1005 Plateau grassland, uncommon.
E. leontoglossa Reichb.f. 508 Plateau grassland, uncommon.
E. ovalis Lindl. subsp. *bainesii* (Rolfe) Hall 509 Plateau grassland, uncommon.
E. welwitschii (Reichb.f.) Rolfe 577 Plateau grassland, uncommon.

DICOTYLEDONEAE

PIPERACEAE

- Peperomia tetraphylla* (G.Forst.) Hook. & Arn. 651 Kloof, against rock crevices, rare.

ULMACEAE

- Celtis africana* Burm.f. L11, L12, 21 Kloof, common.

PROTEACEAE

- Protea caffra* Meisn. L155, 365 Rocky quartzite hills, south-facing slopes, common.
P. roupelliae Meisn. 584 Top of kloof, nearly on plateau, rare.

LORANTHACEAE

- Viscum rotundifolium* L.f. L106, 371 Parasite on trees, bushy areas, occasional.

SANTALACEAE

- Osyris lanceolata* Hochst. & Steud. L358, 16, 186 Kloof, uncommon.
Thesium burkei A.W.Hill 175 Grassland, occasional.
T. gracilarioides A.W.Hill 296 Grassland, occasional.
T. impeditum A.W.Hill L15A Grassland, occasional.
T. magalismontanum Sond. 809 Grassland, occasional.
T. transvaalense Schltr. 117 Grassland, occasional.
T. utile A.W.Hill 927 Grassland, occasional.

POLYGONACEAE

- Rumex crispus* L. 394 Along streambank, uncommon.
R. sagittatus Thunb. 757 Along streambank, uncommon.
Polygonum pulchrum Blume L99, 548 Along streambank, uncommon.
P. salicifolium Willd. 594 Along streambank, uncommon.

CHENOPODIACEAE

- Chenopodium album* L. L172 Disturbed area, occasional.
C. schraderianum Roem. & Schult. L252 Disturbed area, occasional.
Atriplex semibaccata R.Br. 530 Thornveld, uncommon.

AMARANTHACEAE

- Cyathula uncinulata* (Schrad.) Schinz 403, 901B Grassland, south-facing slopes, uncommon.
Pupalia lappacea (L.) Juss. 860 Bushy area, uncommon.
Achyranthes aspera L. 460, 465 Kloof, common.
A. sicula (L.) All. L112 Bushy area, uncommon.
Brayulinea densa (Humb. & Bonpl.) Small 523 Disturbed area, common.
Alternanthera pungens H.B.K. L122, 522 Disturbed area, common.
Gomphrena celosioides Mart. L348 Disturbed area, common.

AIZOACEAE

- Limeum aethiopicum* Burm. L246 Bushy area, uncommon.
Psammotropha myriantha Sond. 204, 1078 Plateau grassland, occasional.

MESEMBRYANTHEMACEAE

- Ruschia hamata* (L.Bol.) Schwant. 591 Rocky area, plateau, uncommon.
Khadia acutipetala (N.E.Br.) N.E.Br. 875 Rocky area, plateau, uncommon.
Delosperma mahonii (N.E.Br.) N.E.Br. 470 Rocky area, plateau, uncommon.

PORTULACACEAE

- Talinum caffrum* (Thunb.) Eckl. & Zeyh. 1010 Thornveld, uncommon.

CARYOPHYLLACEAE

- Cerastium capense* Sond. 852 Kloof, in water, rare.
Pollichia campestris Ait. 940, 976 Grassland, common.
Silene burchellii Otth L260, 200 Grassland, occasional.
S. undulata Ait. 785 Grassland, uncommon.
Dianthus micropetalus Ser. 198 Grassland, occasional.

RANUNCULACEAE

- Clematis brachiata* Thunb. L16, 657 Thornveld, occasional.
Ranunculus multifidus Forsk. 317, 397 Marshy area, uncommon.

MENISPERMACEAE

- Antizoma angustifolia* (Burch.) Miers ex Harv. L391, 1017 Thornveld, uncommon.

BRASSICACEAE (Cruciferae)

- Heliophila rigidiuscula* Sond. 292 South-facing slopes of rocky quartzite hills, occasional.
Sisymbrium turchaninowii Sond. 819 South-facing slope, grassland, uncommon.

CAPPARACEAE

- Cleome hirta* (Klotzsch) Oliv. L210 Grassland, uncommon.
C. maculata (Sond.) Szyzyl. 313 Grassland, uncommon.
C. rubella Burch. 691 Grassland, uncommon.
Boscia albitrunca (Burch.) Gilg & Ben. L390, 822 Bushy area, north-facing slope, rare.
Maerua cafra (DC.) Pax L408, L445, 485 Bushy area, north-facing slope, uncommon.

CRASSULACEAE

- Cotyledon wickensii* Schonl. 885 Rocky quartzite hills, uncommon.
Kalanchoe paniculata Harv. L169, 882 Rocky quartzite hills, uncommon.
K. rotundifolia Haw. 1013, 1033 Thornveld, occasional.
K. thyrsiflora Harv. 882A Grassland, rocky areas, occasional.
Crassula alba Forsk. var. *alba* L55, 677 Grassland, mountain slopes, occasional.
C. capitella Thunb. subsp. *nodulosa* (Schonl.) Tölken 362, 1074 Plateau, rocky area, uncommon.
C. globularioides Britt. subsp. *argyrophylla* (Schonl. & Bak.f.) Tölken 773 Rocky quartzite hills, occasional.
C. schimperi Fischer & C.A.Mey. var. *lanceolata* (Eckl. & Zeyh.) Tölken 601 Rocky quartzite hills, occasional.
C. setulosa Harv. L162, L291, 690 Grassland, mountain slopes, occasional.
Adromischus umbraticola C.A.Sm. 363 Rocky quartzite hills, occasional.

VAHLIACEAE

- Vahlia capensis* (L.f.) Thunb. L338 Bushy area, uncommon.

PITTOSPORACEAE

Pittosporum viridiflorum Sims L407, 277, 352, 541 Kloof, occasional.

MYROTHAMNACEAE

Myrothamnus flabellifolius Welw. 197 Plateau, rocky areas, uncommon.

ROSACEAE

Rubus pinnatus Willd. 123 Kloof, common.

R. rigidus Sm. L101, 170 Kloof, common.

Agrimonia odorata Mill. L308, 396 Along streams, uncommon.

Leucosidea sericea Eckl. & Zeyh. L24, 5 Kloof, common.

Cliffortia linearifolia Eckl. & Zeyh. L235 Kloof, uncommon.

C. nitidula (Engl.) R.E. & Th.Fr.jr. subsp. *pilosa* Weim. L37, 725 Kloof, uncommon.

C. repens Schltr. 151, 218, 843 Kloof, uncommon.

MIMOSACEAE

Acacia caffra (Thunb.) Willd. L230, 70 North-facing slopes, common.

A. karroo Hayne L232, 360 Thornveld, common.

Elephantorrhiza elephantina (Burch.) Skeels L177, 99 Grassland, abundant.

CAESALPINIACEAE

Cassia biensis (Steyaert) Mendonca & Torre 539 Grassland, occasional.

PAPILIONACEAE

Calpurnia sericea Harv. L446, 510, 583 Grassland, uncommon.

Lotononis calycina (E.Mey.) Benth. var. *hirsutissima* Dümmer 524, 950 Plateau grassland, uncommon.

L. foliosa H.Bol. 1372, L372, 166 Plateau grassland, common.

L. laxa Eckl. & Zeyh. 846 Plateau grassland, uncommon.

Pearsonia cajanifolia (Harv.) Polhill. 276, 426, 682 Plateau, uncommon.

P. sessilifolia (Harv.) Dümmer 958 Grassland, uncommon.

Dichilus gracilis Eckl. & Zeyh. L332 Grassland, uncommon.

D. lebeckioides DC. 400 Plateau grassland, uncommon.

D. strictus E. Mey. 307, 1071 Plateau grassland, uncommon.

Melolobium obcordatum Harv. 437 Plateau grassland, uncommon.

M. wilmsii Harms 543 Plateau grassland, uncommon.

Crotalaria distans Benth. 715 Plateau grassland, uncommon.

Argyrobium pauciflorum Eckl. & Zeyh. L114 Plateau grassland, uncommon.

A. rupestre (E.Mey.) Walp. L225, 152, 1052 Plateau grassland, uncommon.

A. tomentosum (Andr.) Druce 211 Plateau grassland, uncommon.

A. tuberosum Eckl. & Zeyh. 417 Plateau grassland, uncommon.

Trifolium africanum Ser. var. *africanum* 91 Grassland, uncommon.

T. africanum Ser. var. *glabellum* (E.Mey.) Harv. 418 Grassland, uncommon.

T. pratense L. 551 Grassland, uncommon.

Lotus discolor E.Mey. 261, 546, 991 Plateau grassland, uncommon.

Indigofera acutispala Conrath 401 Plateau grassland, uncommon.

I. comosa N.E.Br. 196 Rocky quartzite hills, occasional.

I. foliosa E.Mey. L149 Rocky quartzite hills, occasional.

I. hedyantha Eckl. & Zeyh. L145, 928 Plateau grassland, uncommon.

I. hilaris Eckl. & Zeyh. 163, 212, 872, 908 Plateau grassland, uncommon.

I. inhambanensis Klotzsch L147 Grassland, uncommon.

I. langebergensis L.Bol. L721A Grassland, uncommon.

I. sp. cf. I. obscura N.E.Br. 1047 Grassland, uncommon.

I. sanguinea N.E.Br. 302, 972 Plateau grassland, uncommon.

- Indigofera spicata* Forsk. 759 Plateau grassland, uncommon.
I. zeyheri Spreng. ex Eckl. & Zeyh. 946, 1025 Plateau grassland, occasional.
Psoralea foliosa Oliv. L400 Plateau grassland along stream, occasional.
P. polysticta Benth. L221, 155, 340 Plateau grassland along stream, occasional.
Tephrosia capensis (Jacq.) Pers. L331, 902, 943, 964 Grassland, uncommon.
T. elongata E.Mey. var. *elongata* L75A, 956 Grassland, uncommon.
T. longipes Meisn. var. *longipes* L290, 699, 857, 869 Rocky quartzite hills, uncommon.
T. semiglabra Sond. 107, 140 Grassland, uncommon.
Mundulea sericea (Willd.) A.Chev. L27, L82, 221 Rocky quartzite hills, occasional.
Zornia linearis E.Mey. L212, 229, 915, 933 Grassland, uncommon.
Dalbergia melanoxylon Guill. & Perr. L402 Bushy area, uncommon.
Abrus laevigatus E.Mey. 1040 Plateau grassland, uncommon.
Erythrina zeyheri Harv. 356 Grassland, uncommon.
Rhynchosia adenodes Eckl. & Zeyh. 103, 135 Grassland, uncommon.
R. monophylla Schltr. 867, 938 Grassland, uncommon.
R. nervosa Benth. & Harv. 993 Plateau grassland, uncommon.
R. reptabunda N.E.Br. 63 Grassland, uncommon.
R. totta (Thunb.) DC. 399, 941 Plateau grassland, uncommon.
Eriosema cordatum E.Mey. 132, 910, 1049 Plateau grassland, uncommon.
E. salignum E.Mey. L224, 269, 1053 Plateau grassland, uncommon.
Vigna vexillata (L.) A.Rich. 330, 436 Grassland, uncommon.
Sphenostylis angustifolia Sond. L325, 214 Grassland, uncommon.
Dolichos falciformis E.Mey. 174, 590 Grassland, uncommon.

GERANIACEAE

- Geranium incanum* Burm.f. 314, 409 Grassland, uncommon.
Monsonia angustifolia E.Mey. ex A.Rich. L156, 709 Plateau grassland, occasional.
M. attenuata Harv. 615 Plateau grassland, occasional.
M. biflora DC. L124 Plateau grassland, occasional.
Pelargonium alchemilloides (L.) Ait. 818 Bushy area, uncommon.
P. luridum (Andr.) Sweet L229, 205 Grassland, occasional.
P. transvaalense Kunth 502 Bushy area, uncommon.

OXALIDACEAE

- Oxalis corniculata* L. L135, 385, 1030 Grassland, uncommon.
O. depressa Eckl. & Zeyh. L359 Bushy area, uncommon.
O. obliquifolia Steud. ex A.Rich. 334 Bushy area, uncommon.

LINACEAE

- Linum thunbergii* Eckl. & Zeyh. 462 Grassland, rare.

RUTACEAE

- Zanthoxylum capense* (Thunb.) Harv. L18, 291 Kloof, occasional.

MALPIGHIACEAE

- Sphegamnocarpus galphimiiifolius* (A.Juss.) Szyszyl. subsp. *galphimiiifolius* L23, L284,
 L289 Rocky quartzite hills, occasional.
S. transvaalicus (Kuntze) Burtt Davy 482 Rocky quartzite hills, rare.

POLYGALACEAE

- Polygala amarymbica* Eckl. & Zeyh. 942 Grassland, occasional.
P. hottentotta Presl L165, 102 Grassland, occasional.
P. uncinata E.Mey. 180, 811 Grassland, occasional.
P. virgata Thunb. var. *virgata* 802 Grassland, occasional.
P. virgata Thunb. var. *decora* (Sond.) Harv. 255 Grassland, occasional.

EUPHORBIACEAE

- Phyllanthus glaucophyllus* Sond. 100 Grassland, occasional.
P. parvulus Sond. 428 Grassland, abundant.
Acalypha angustata Sond. var. *glabra* Sond. L365 Grassland, occasional.
A. caperonioides Baill. L141, 298 Rocky quartzite hills, rare.
A. punctata Meisn. 121, 122 Grassland, occasional.
Clusia pulchella L. L30, L244, 233, 765 Rocky quartzite hills, abundant.
C. hirsuta E.Mey. ex Sond. L379, 165 South-facing slopes, Ventersdorp System, rare.
Euphorbia epicyparissias E.Mey. ex Boiss. L281, 2 South-facing slopes, Ventersdorp System, occasional.
E. clavarioides Boiss. var. *truncata* (N.E.Br.) White, Dyer & Sloane 709B Plateau grassland, rare.
E. inaequilatera Sond. L120 Plateau grassland, rare.
E. striata Thunb. 115 Plateau grassland, rare.

ANACARDIACEAE

- Rhus discolor* E.Mey L43, L151, L152, 202 Plateau grassland, common.
R. sp. cf. R. divaricata Eckl. & Zeyh. 256, 914 South-facing slopes, grassland, uncommon.
R. eckloniana Sond. 176, 488 South-facing slopes, grassland, uncommon.
R. sp. cf. R. engleri Britt. 183 South-facing slopes, grassland, uncommon.
R. intermedia Schonl. L15, L19, L157, 153 Kloof, uncommon.
R. leptodictya Diels L361, 144, 355 South-facing slopes, occasional.
R. magalismontana Sond. L205, L277, 64 Rocky quartzite hills, common.
R. sp. cf. R. montana Diels var. *montana* 792 Grassland, uncommon.
R. pyroides Burch. L360, 51, 97, 332 Kloof, common.
R. rehmanniana Engl. 816 Bushy area, uncommon.
R. rogersii Schonl. 791 Grassland, uncommon.
R. transvaalensis Engl. 184 Rocky hills, uncommon.
R. zeyheri Sond. L42 Grassland, uncommon.

AQUIFOLIACEAE

- Ilex mitis* (L.) Radlk. L440, 342, 350, 706 Kloof, rare.

CELASTRACEAE

- Maytenus heterophylla* (Eckl. & Zeyh.) N.K.B. Robson L48, L450, 30, 384 Mountain slopes, occasional.
M. polyacantha (Sond.) Marais L14, 143 North-facing slopes, common.
Putterlickia pyracantha (L.) Endl. ex Jackson L383 Mountain slopes, uncommon.
Cassine aethiopica Thunb. L389, L394, 372, 447 Mountain slopes, uncommon.
C. burkeana (Sond.) Kuntze 808 Mountain slopes, uncommon.

ICACINACEAE

- Cassinopsis ilicifolia* (Hochst.) Kuntze L399, 39 Kloof, occasional.

SAPINDACEAE

- Pappea capensis* Eckl. & Zeyh. L442, 366, 367 Mountain slopes, uncommon.

RHAMNACEAE

- Ziziphus mucronata* Willd. 43 Thornveld, occasional.
Z. zeyherana Sond. 134 Grassland, occasional.
Rhamnus prinoides L'Hérit. L34, 14, 603 Kloof, occasional.
Helinus integrifolius (Lam.) Kuntze L376, 383, 483 Bushy areas, mountain slopes, uncommon.

VITACEAE

Rhoicissus tridentata (L.f.) Wild & Drumm. L44, 146, 376, 739 Mountain slopes, common.

TILIACEAE

Corchorus confusus Wild 266, 318, 416 Grassland, uncommon.

Grewia occidentalis L. L108, L137, 187, 254 Kloof, occasional.

MALVACEAE

Abutilon sonneratianum (Cav.) Sweet L138 Grassland, uncommon.

Sida chrysantha Ulbr. 414, 989, 1039 Grassland, uncommon.

S. dregei Burt Davy L131, 265, 423A Grassland, uncommon.

S. ternata L.f. 503 Grassland, uncommon.

Pavonia burchellii (DC.) R. A. Dyer L392, 319, 374, 443 Bushy area, uncommon.

Hibiscus aethiopicus L. var. *ovatus* Harv. 133, 999, 1007 Grassland, uncommon.

H. calyphyllus Cav. L185, 440, Kloof, uncommon.

H. sp. cf. H. engleri K.Schum. 859 Kloof, uncommon.

H. pusillus Thunb. L25A, L190, 1011 Grassland, common.

H. trionum L. L127 Grassland, common.

STERCULIACEAE

Melhanie prostrata DC. L183, 532 Grassland, rocky area, uncommon.

Dombeya rotundifolia (Hochst.) Planch. L22, L198, 12 Kloof, occasional.

Hermannia betonicifolia Eckl. & Zeyh. L351, 228 Grassland, uncommon.

H. depressa N.E.Br. L72, 101 Grassland, uncommon.

H. floribunda Harv. 442, 821 Grassland, uncommon.

H. geniculata Eckl. & Zeyh. 189 Grassland, uncommon.

H. grandistipula (Buching. ex Hochst.) K.Schum. 188, 471 Grassland, uncommon.

H. lancifolia Szyszyl. L336, L458, 33 Grassland, uncommon.

CLUSIACEAE (Guttiferae)

Hypericum aethiopicum Thunb. subsp. *sonderi* (Bred.) N.K.B. Robson 742, 1035 Grassland, uncommon.

H. lalandii Choisy 310 Grassland, uncommon.

ELATINACEAE

Bergia decumbens Planch. ex Harv. 413, 710, 998 Grassland, uncommon.

FLACOURTIACEAE

Kiggelaria africana L. L318, 17, 124, Kloof, occasional.

Scolopia zeyheri (Nees) Harv. L378, L396, L406, 20 Mountain slopes, uncommon.

THYMELAEACEAE

Gnidia capitata L.f. 35, 41, 58, 118 Grassland, occasional.

G. gymnostachya (C.A.Mey.) Gilg 131 Grassland, occasional.

G. kraussiana Meisn. 839 Grassland, occasional.

Lasiosiphon caffer Meisn. 192, 838 Grassland, occasional.

LYTHRACEAE

Nesaea sagittifolia (Sond.) Koehne 650 Plateau grassland, stream bank, uncommon.

N. schinzii Koehne var. *rehmannii* Koehne 713, 1048 Plateau grassland, streambank, uncommon.

ONAGRACEAE

- Epilobium hirsutum* L. 654 Plateau grassland, streambank, uncommon.
Oenothera indecora Camb. 93 Grassland, uncommon.
O. rosea L'Hérit. ex Ait. 87, 544 Grassland, uncommon.
O. tetraptera Cav. 112, 357 Grassland, uncommon.

HALORAGIDACEAE

- Gunnera paniculata* L. L305, 329 Marshy area, uncommon.

ARALIACEAE

- Cussonia paniculata* Eckl. & Zeyh. L47, 23 Mountain slopes, occasional.

APIACEAE (Umbelliferae)

- Centella coriacea* Nannfd. 311 Grassland, in stream, uncommon.
Heteromorpha arborescens (Spreng.) Cham. & Schlecht. L17, 678 Kloof, common.
Bupleurum mundii Cham. & Schlecht. 581, 834 Mountain slopes, uncommon.
Pimpinella transvaalensis Wolff 614 Plateau grassland, uncommon.
Sium repandum Welw. ex Hiern L243, 754 Kloof, in stream, uncommon.
Peucedanum magalismontanum Sond. 393 Grassland, uncommon.
Annesorrhiza flagellifolia Burt Davy L374 Grassland, uncommon.

MYRSINACEAE

- Myrsine africana* L. L28, L369, 10 Kloof, common.
M. pillansii Adamson L441 Kloof, rare.

SAPOTACEAE

- Bequaertiodendron magalismontanum* (Sond.) Heine & J.H.Hemsl. L29, 55 Rocky quartzite hills, north-facing slopes, common.

EBENACEAE

- Euclea crispa* (Thunb.) Guerke var. *crispa* L129, L35, 50, 52 Kloof, common.
E. natalensis A.DC. L317, 421 Kloof, uncommon.
Diospyros austro-africana De Wint. var. *microphylla* (Burch.) De Wint. 139, 148, 280, 475 Kloof, occasional.
D. lycioides Desf. subsp. *guerkei* (Kuntze) De Wint. L13, L404, 11, 38 Kloof, common.
D. whyteana (Hiern) F.White L105, 49 Kloof, occasional.

OLEACEAE

- Olea africana* Mill. L109, L227, 156, 185 Kloof, occasional.
Menodora africana Hook. 105 Grassland, uncommon.

LOGANIACEAE

- Nuxia congesta* R.Br. ex Fresen. L32, L326, 45 Rocky quartzite hills, occasional.
Buddleia saligna Willd. L384, 359 North-facing slopes, occasional.
B. salviifolia (L.) Lam. L38, 4 Kloof, uncommon.

GENTIANACEAE

- Sebaea grandis* (E.Mey.) Steud. 751 Plateau grassland, uncommon.
S. leiostyla Gilg L222, 680 Plateau grassland, uncommon.
Chironia purpurascens (E.Mey.) Benth. & Hook.f. subsp. *humilis* (Gilg) Verdoorn 312, 335, 538 Plateau grassland, uncommon.

APOCYNACEAE

- Carissa bispinosa* (L.) Desf. ex Brenan var. *bispinosa* L382, 382 Mountain slopes, uncommon.
Landolphia capensis Oliv. 36 Rocky quartzite hills, common.

ASCLEPIADACEAE

- Cryptolepis oblongifolia* (Meisn.) Schltr. L287, L303 Grassland, uncommon.
Raphionacme hirsuta (E.Mey.) R.A.Dyer ex Phill. 201, 992 Rocky areas, plateau grassland, uncommon.
Xysmalobium parviflorum Harv. ex Scott 206 Grassland, uncommon.
X. undulatum (L.) Ait.f. 513 Grassland, uncommon.
Schizoglossum corniculatum (E.Mey.) R.A.Dyer L125, 427 Grassland, uncommon.
Pachycarpus schinzianus N.E.Br. 210, 851 Grassland, uncommon.
Asclepias affinis (Schltr.) Schltr. 995 Grassland, uncommon.
A. cultiformis Harv. ex Schltr. 534 Grassland, uncommon.
A. decipiens N.E.Br. 224 Grassland, uncommon.
A. eminens (Harv.) Schltr. 644 Grassland, uncommon.
A. fruticosa L. L448 Grassland, uncommon.
A. gibba (E.Mey.) Schltr. 369 Grassland, uncommon.
A. physocarpa (E.Mey.) Schltr. 232 Grassland, uncommon.
A. stellifera Schltr. 80, 190 Grassland, uncommon.
Pentarrhinum insipidum E.Mey. 953 Bushy area, uncommon.
Cynanchum virens Dietr. 457 Bushy area, uncommon.
Brachystelma circinatum E.Mey. 253 Grassland, uncommon.
Ceropegia rendallii N.E.Br. 529 Bushy area, uncommon.
Riocreuxia polyantha Schltr. 893 Kloof, occasional.
Stapelia leendertziae N.E.Br. L319, 689 Rocky mountain slopes, uncommon.
Tenaris chlorantha Schltr. 901 Kloof, uncommon.

CONVOLVULACEAE

- Cuscuta campestris* Yunck. L139 Grassland, uncommon.
Convolvulus natalensis Bernh. var. *transvaalensis* (Schltr.) A.Meeuse 644A, 644B Grassland, uncommon.
C. thunbergii Roem. & Schult. 939 Grassland, uncommon.
C. sagittatus Thunb. var. *ulosepalus* (Hall.f.) Verdc. 164 Grassland, uncommon.
Ipomoea atherstonei Bak. L201, L328 Grassland, uncommon.
I. bathycolpos Hall.f. var. *bathycolpos* 273, 711, 1028 Grassland, uncommon.
I. crassipes Hook. L160, 274 Grassland, common.
I. obscura (L.) Ker-Gawl. var. *fragilis* (Choisy) A.Meeuse 226, 981, 1022 Grassland, uncommon.
I. omaneyi Rendle 227 Grassland, uncommon.
Turbina oblongata (E.Mey. ex. Choisy) A.Meeuse L27A, 391, 708 Grassland, uncommon.

BORAGINACEAE

- Ehretia rigida* (Thunb.) Druce L386, L447, 126, 647 Mountain slopes, occasional.
Cynoglossum enerve Turcz. L265, 84 Grassland, uncommon.
C. lanceolatum Forsk. 594 Grassland, uncommon.
Lithospermum cinereum DC. L78, 959 Grassland, uncommon.

VERBENACEAE

- Verbena bonariensis* L. L246, 554, 781 Marshy area, uncommon.
V. officinalis L. 13 Marshy area, uncommon.
Lantana rugosa Thunb. L60, 136, 402 Bushy area, common.
Lippia javanica (Burm.f.) Spreng. L380, L387, 379 Bushy area, common.

- L. scaberrima* Sond. 398 Bushy area, uncommon.
Chascanum adenostachyum (Schauer) Moldenke 528 Grassland, uncommon.
C. pinnatifidum (L.f.) E.Mey. 459 Grassland, uncommon.
Priva meyeri Jaub. & Spach 531, 1027 Bushy area, uncommon.
Clerodendrum myricoides (Hochst.) Vatke 299, 351 Kloof, uncommon.
C. triphyllum (Harv.) Pearson 141, 236 Grassland, uncommon.

LAMIACEAE (Labiatae)

- Ajuga ophrydis* Burch. ex Benth. L266, 34, 116 Grassland, occasional.
Teucrium trifidum Retz L61, L346, 193, 257 Thornveld, common.
Leonotis microphylla Skan 337, 444 Rocky quartzite hills, occasional.
Stachys hyssopoides Burch. ex Benth. 120, 432 Grassland, uncommon.
Salvia runcinata L.f. L62, 233 Grassland, uncommon.
Satureia biflora (Buch. Ham. ex D.Don) Briq. 832, 1006 Grassland, uncommon.
Mentha longifolia Huds. 395 Grassland, uncommon.
Aeolanthus canescens Guerke 797, 1066 Plateau grassland, rocky area, uncommon.
Pycnostachys reticulata (E.Mey.) Benth. L239, 698 Grassland, streambank, uncommon.
Plectranthus hereroensis Engl. 815 Kloof, uncommon.
P. madagascariensis (Pers.) Benth. 585 Rocky area, plateau, uncommon.
Hemizygia bracteosa (Benth.) Briq. L245 Rocky quartzite hills, uncommon.
H. canescens (Guerke) Ashby 762, 879 Rocky quartzite hills, uncommon.
Becium angustifolium (Benth.) N.E.Br. 934 Grassland, uncommon.
B. obovatum (E.Mey. ex Benth.) N.E.Br. L209, 66, 172 Grassland, common.

SOLANACEAE

- Withania somnifera* (L.) Dun. 30, 540, 588 Grassland, uncommon.
Physalis angulata L. L349 Grassland, uncommon.
Solanum incanum L. L397, 425, 883, 977 Grassland, common.
S. leucophaeum Dun. 1018 Thornveld, uncommon.
S. panduraeforme E.Mey. L253, L333, 167 Grassland, common.
S. pseudo-capsicum L. L20, L453 Grassland, uncommon.
S. sp. cf. S. renschii Vatke L375 Grassland, uncommon.
S. retroflexum Dun. L133, 597, 758 Kloof, uncommon.
S. rigescens Jacq. L31, 294, 370, 858 Mountain slopes, uncommon.
S. sisymbriifolium Lam. L350 Grassland, uncommon.
Datura stramonium L. L256, 1003 Disturbed area, uncommon.

SCROPHULARIACEAE

- Apotosimum indivisum* Burch. 142 Grassland, uncommon.
Nemesia fruticans (Thunb.) Benth. L355, 181 Grassland, uncommon.
N. melissaefolia Benth. 293 Grassland, uncommon.
Diclis reptans Benth. 85, 433, 850 Grassland, uncommon.
Halleria lucida L. L279, L405, 31 Kloof, occasional.
Manulea bellidifolia Benth. 957 Grassland, uncommon.
Sutera aurantiaca (Burch.) Hiern 8, 119 Grassland, uncommon.
S. caerulea (L.f.) Hiern L296, 445, 694 Grassland, uncommon.
Zaluzianskya capensis Walp. L211 Grassland, uncommon.
Z. katharinae Hiern 795 Grassland, uncommon.
Z. lychnidea Walp. 450 Grassland, uncommon.
Mimulus gracilis R.Br. 545 Grassland, uncommon.
Limosella maior Diels 434 Grassland, uncommon.
Craterostigma wilmsii Engl. 364 Grassland, uncommon.
Alectra sessiliflora (Vahl) Kuntze 429, 535 Grassland, uncommon.
Graderia subintegra Mast. 230 Grassland, uncommon.
Sopubia cana Harv. 856 Grassland, uncommon.

- Buchnera longespicata* Schinz 745 Grassland, uncommon.
Striga asiatica (L.) Kuntze 281 Grassland, uncommon.
S. bilabiata (Thunb.) Kuntze L352, 279 Grassland, uncommon.
S. elegans Benth. L46, 282 Grassland, uncommon.
S. gesnerioides (Willd.) Vatke ex Engl. 812, 813 Grassland, uncommon.

SELAGINACEAE

- Hebenstreitia dentata* L. L323 Grassland, uncommon.
H. elongata H.Bol. L412, 67, 160 Grassland, uncommon.
H. integrifolia L. 764 Rocky quartzite hills, occasional.
Selago capitellata Schltr. L414, 728 Grassland, uncommon.
S. wilmsii Rolfe 747 Grassland, uncommon.
Walafrida densiflora (Rolfe) Rolfe 895 Grassland, uncommon.
W. saxatilis (E.Mey.) Rolfe L128, L213 Grassland, uncommon.

GESNERIACEAE

- Streptocarpus vandeureurii* Back.f. & S.Moore 331 Rocky quartzite hills, abundant.

ACANTHACEAE

- Thunbergia hirta* Sond. 368, 526 Bushy area, north-facing slopes, uncommon.
Chaetanctanthus burchellii Nees 195 Grassland, uncommon.
C. costatus Nees 130 Grassland, uncommon.
C. setiger (Pers.) Lindl. L40A Grassland, uncommon.
Ruellia cordata Thunb. 173, 448, 975 Bushy area, north-facing slopes, uncommon.
R. malacophylla C.B.Cl. L136 Bushy area, north-facing slopes, uncommon.
Crabbea acaulis N.E.Br. L115, 955 Grassland, common.
C. hirsuta Harv. L335, L342, 1050 Grassland, uncommon.
Barleria macrostegia Nees 723 Bushy area, uncommon.
B. obtusa Nees 741 Bushy area, uncommon.
Blepharis integrifolia (L.f.) E.Mey. ex Schinz L121, 1031 Bushy area, uncommon.
B. stainbankiae C.B.Cl. L373, 1051, 1060 Bushy area, uncommon.
Hypoestes verticillaris (L.f.) R.Br. ex C.B.Cl. L59, 674 Kloof, uncommon.
Isoglossa grantii C.B.Cl. 673, 820, 899 Bushy area, north-facing slopes, common.
I. origanoides (Nees) Lindau 1023 Bushy area, north-facing slopes, uncommon.
Justicia anagalloides T.Anders. L88A, L117, 222, 884 Grassland, uncommon.
Monechma sp. L171 Grassland, uncommon.

PLANTAGINACEAE

- Plantago lanceolata* L. 553 Marshy area, uncommon.
P. longissima Decne. 542 Marshy area, uncommon.

RUBIACEAE

- Kohautia amatymbica* Eckl. & Zeyh. 7, 114 Grassland, uncommon.
K. sp. cf. K. virgata (Willd.) Brem. L167 Grassland, uncommon.
Oldenlandia herbacea (L.) Roxb. L364, 129 Rocky areas, plateau, uncommon.
Pentania angustifolia (Hochst.) L353, 83, 169 Grassland, occasional.
P. prunelloides (Klotzsch ex Eckl. & Zeyh.) Walp. 168 Grassland, occasional.
Vangueria infausta Burch. L283, L322, 56 Rocky quartzite hills, occasional.
Pygmaeothamnus zeyheri (Sond.) Robyns var. *rogersii* Robyns 814 Grassland, rocky area, uncommon.
Tapiphyllum parvifolium (Sond.) Robyns L25, 57 Rocky quartzite hills, common.
Canthium gilfillanii (N.E.Br.) O.B.Miller L385, 44, 46, 127 Rocky quartzite hills, common.
C. mundianum Cham. & Schlechtd. L26, 125 Rocky quartzite hills, common.
Pachystigma pygmaeum (Schltr.) Robyns 602, 685 Grassland, uncommon.

- Pavetta assimilis* Sond. L385, 48 Kloof, occasional.
P. assimilis Sond. var. *pubescens* Brem. L33, L193, 375 Kloof, occasional.
Galopina circaeoides Thunb. 595, 817 Kloof, uncommon.
Anthospermum hispidulum D.Mey. ex Harv. & Sond. L324, 862, 876, 878 Grassland, common.
A. rigidum Eckl. & Zeyh. L77, 388, 868, 912, 920 Grassland, common.
Richardia brasiliensis (Moq.) Gomez 234 Grassland, common.
Galium capense Thunb. 86, 438, 980 Grassland, common.
G. horridum Thunb. L228 Grassland, common.
Rubia petiolaris DC. 373 Kloof, occasional.

VALERIANACEAE

- Valeriana capensis* Thunb. 550 Marshy area, grassland, uncommon.

DIPSACACEAE

- Scabiosa columbaria* L. L5A, L366, 113 Grassland, occasional.

CUCURBITACEAE

- Zehneria scabra* (L.f.) Sond. L36 Grassland, uncommon.
Mukia maderaspatana (L.) M.J. Roem. L370 Grassland, uncommon.
Kedrostis africana (L.) Cogn. L107, 456, 1019 Grassland, uncommon.
K. hirtella (Naud.) Cogn. L409 Grassland, uncommon.
Cucumis hirsutus Sond. 997 Grassland, uncommon.
C. myriocarpus Naud. L267 Grassland, uncommon.
C. prophetarum L. subsp. *zeyheri* (Sond.) Jeffrey 1029 Thornveld, uncommon.
Trochomeria debilis (Sond.) Hook.f. 1032 Grassland, uncommon.
Peponium caledonicum (Sond.) Engl. 404 Plateau, rocky area, uncommon.

CAMPANULACEAE

- Wahlenbergia caledonica* Sond. 918 Marshy area, grassland, uncommon.
W. undulata A.DC. 688 Marshy area, grassland, uncommon.
W. virgata Engl. 77 Marshy area, grassland, uncommon.
W. sp. cf. W. zeyheri Eckl. & Zeyh. L254 Marshy area, grassland, uncommon.
Lobelia decipiens Sond. 431 Marshy area, grassland, uncommon.
L. depressa L.f. 415 Marshy area, grassland, uncommon.
L. filiformis Lam. var. *krebsiana* (Presl) E.Wimm. 547 Marshy area, grassland, uncommon.
L. nuda Hemsl. L302, 309 Marshy area, grassland, uncommon.

ASTERACEAE (Compositae)

- Vernonia capensis* (Houtt.) Druce L148 Grassland, uncommon.
V. hirsuta (DC.) Sch.Bip. 854 Plateau grassland, uncommon.
V. galpinii Klatt. 40, 65, 191 Grassland, uncommon.
V. natalensis Sch.Bip. 184, 209 Plateau grassland, common.
V. oligocephala (DC.) Sch.Bip. ex Walp. L371, 92, 157, 378 Plateau grassland, common.
V. staehelinoides Harv. L218, L251, 697, 864 Rocky quartzite hills, common.
V. sutherlandii Harv. 225, 863, 871 Rocky quartzite hills, common.
Aster bakerianus Burt Davy ex C.A.Sm. L52, 616 Plateau grassland, uncommon.
A. harveyanus Kuntze 161 Plateau grassland, uncommon.
A. peglerae H.Bol. 137 Plateau grassland, uncommon.
Felicia filifolia (Vent.) Burt Davy subsp. *filifolia* L90, 1 Grassland, common.
F. muricata (Thunb.) Nees L63, 9 Mountain slopes, common.
Nidorella anomala Steetz L50, 344, 358 Plateau grassland, occasional.
N. hottentotica DC. 297, 930, 983 Grassland, uncommon.

- Nidorella resedifolia* DC. 894 Grassland, uncommon.
Conyza bonariensis (L.) Cronq. 904B Disturbed area, uncommon.
C. floribunda H.B.K. 720, 1080 Disturbed area, uncommon.
C. hochstetteri Sch.Bip. Grassland, marshy area, uncommon.
C. podocephala DC. L68, 419, 501, 866 Grassland, common.
Chrysocoma tenuifolia Berg. 158, 726, 866, 881 Rocky quartzite hills, abundant.
Brachylaena rotundata S.Moore L236, L403, 128 Kloof, occasional.
Tarchonanthus camphoratus L. L377, 473 Rocky north-facing slopes, abundant.
Gnaphalium luteo-album L. 599 Rocky mountain slopes, uncommon.
G. purpureum L. 596 Along streambank, grassland, uncommon.
G. undulatum L. 173, 672 Along streambank, grassland, uncommon.
Rhynaea phyllifolia DC. L92A Grassland, uncommon.
Helichrysum adscendens (Thunb.) Less. L117A 207, 598, 1057 Plateau grassland, common.
H. athrixifolium (Kuntze) Moeser. L435 Plateau grassland, common.
H. aureo-nitens Sch.Bip. L159, 315 Streambank, rocky quartzite hills, uncommon.
H. aureum (Houtt.) Merrill var. *aureum* L94, L306, 683 Rocky quartzite hills, common.
H. aureum (Houtt.) Merrill var. *monocephalum* (DC.) Hilliard 845 Rocky quartzite hills, uncommon.
H. ceaspitium Sond. 837, 905 Grassland, uncommon.
H. calliconum Harv. 921 Grassland, uncommon.
H. cerastoides DC. L214, 37 Plateau grassland, uncommon.
H. chionosphaerum DC. 203 Plateau grassland, uncommon.
H. coriaceum Sond. L80A, 345 Plateau grassland, uncommon.
H. kraussii Sch.Bip. L413, 727, 756, 932 Rocky quartzite hills, common.
H. kuntzei (Kuntze) Moeser 463, 618 Grassland, uncommon.
H. lepidissimum S.Moore L327, 763, 891, 1059 Rocky quartzite hills, common.
H. miconiifolium DC. 271, 1063 Plateau grassland, common.
H. nudifolium (L.) Less. L58, L347, L455, 500 Plateau grassland, common.
H. rugulosum Less. L368, 264, 461 Grassland, common.
H. setosum Harv. 705, 761 Rocky quartzite hills, common.
H. splendidum (Thunb.) Less. 801 Bushy area, uncommon.
H. stenopterum DC. L247, 755, 804 Streambanks, uncommon.
H. subulifolium Harv. 951 Grassland, uncommon.
Stoebe vulgaris Levyns L194, 54 Grassland, common.
Athrixia elata Sond. 6 Mountain slopes, common.
Geigeria burkei Harv. subsp. *burkei* var. *intermedia* (S.Moore) Merxm. L72A, L82 Grassland, uncommon.
Acanthospermum glabratum (DC.) Wild 906 Grassland, uncommon.
Xanthium strumarium L. 743 Disturbed area, uncommon.
Zinnia peruviana (L.) L. L93, 458 Disturbed area, uncommon.
Bidens bipinnata L. 719 Disturbed area, uncommon.
Schkuhria pinnata (Lam.) Kuntze ex Thellung L110, 559 Disturbed area, uncommon.
Tagetes minuta L. L134, 722 Disturbed area, uncommon.
Achillea millefolium L. 911, L134, 722 Disturbed area, uncommon.
Schistostephium crataegifolium (DC.) Fenzl ex Harv. L22A, 718, 944 Grassland, common.
Artemisia afra Jacq. ex Willd. L226, L410, 766 Mountain slopes, occasional.
Brachymeris athanasioides Hutch. 746 Kloof, rocky quartzite hills, uncommon.
Lopholaena coriifolia (Sond.) Phil. & C.A.Sm. L206, 700 Rocky areas, grassland, common.
Cineraria lobata L'Hérit. 877 Rocky quartzite hills, uncommon.
C. lyrata DC. 796, 829 Rocky quartzite hills, uncommon.
Senecio affinis DC. 499, 753 Grassland, uncommon.
S. asperulus DC. 71, 386 Grassland, uncommon.
S. consanguineus DC. 830, 907, 966 Plateau grassland, uncommon.

- Senecio coronatus* (Thunb.) Harv. L345, L415, 60, 102 Grassland, common.
S. debilis Harv. 90 Grassland, uncommon.
S. cf. S. dregeanus DC. var. *discoideus* DC. 619 Grassland, common.
S. erubescens Ait. 208, 552, 929 Grassland, common.
S. glanduloso-pilosus Volken & Muschl. 72, 89 Grassland, uncommon.
S. hastatus L. 219 Grassland, uncommon.
S. hieracioides DC. L51, L78A, L457, 617 Grassland, uncommon.
S. inaequidens DC. 904 Grassland, uncommon.
S. inornatus DC. L53, 967 Plateau grassland, uncommon.
S. isatideus DC. L56, 417 Plateau grassland, uncommon.
S. matricariaefolius DC. 787 Plateau grassland, uncommon.
S. othonniflorus DC. 138, 965, 1004 Plateau grassland, uncommon.
S. oxyriifolius DC. 453 Rocky quartzite hills, uncommon.
S. venosus Harv. 361 Rocky quartzite hills, uncommon.
S. verdoorniae R.A.Dyer L110A, 922, 1024 Plateau grassland, uncommon.
S. vimineus DC. 53 Grassland, uncommon.
Euryops transvaalensis Klatt subsp. *transvaalensis* 897 Grassland, uncommon.
Castalis spectabilis (Schltr.) Norl. 42 Grassland, uncommon.
Garuleum pinnatifidum (Thunb.) DC. 154 Grassland, uncommon.
Osteospermum muricatum E.Mey. ex DC. 28, 96 Grassland, uncommon.
Chrysanthemoides monilifera (L.) Norl. L401, 2 Mountain slopes, abundant.
Ursinia nana DC. subsp. *leptophylla* Prassler L140, 220, 231, 769 Rocky quartzite hills, common.
Arctotis arctotoides (L.f.) Lewin 398 Grassland, uncommon.
Haplocarpha scaposa Harv. L41A, 94, 579, 643 Plateau grassland, common.
Apotrochea sp. cf. *A. calendula* (L.) Levyns L116 Plateau grassland, uncommon.
Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessl. 81, 82 Grassland, occasional.
Berkheya pinnatifida (Thunb.) Thell. subsp. *ingrata* (H.Bol.) Roessl. 736 Plateau grassland, occasional.
B. radula (Harv.) De Wild. 421 Plateau grassland, occasional.
B. rhapsantica (DC.) Hutch. & Burtt Davy L356 Plateau grassland, occasional.
B. seminivea Harv. & Sond. L321, 338 Rocky hills, south-facing slopes, abundant.
B. setifera DC. L49, 213, 586, 620 Plateau grassland, abundant.
B. speciosa (DC.) O.Hoffm. subsp. *lanceolata* Roessl. 1082 Plateau grassland, occasional.
B. zeyheri (Sond. & Harv.) Oliv. & Hiern subsp. *zeyheri* L146, 275, 536 Grassland, occasional.
Cirsium vulgare (Savi) Ten. L309, 412 Grassland, occasional.
Dicoma anomala Sond. L204, L343, 681, 913 Plateau grassland, occasional.
D. macrocephala DC. L71 Grassland, uncommon.
D. zeyheri Sond. 537, 716 Plateau grassland, occasional.
Gerbera viridifolia (DC.) Sch.Bip. 79 Grassland, occasional.
Piloselloides hirsuta (Forsk.) C.Jeffrey 73 Grassland, occasional.
Tolpis capensis (L.) Sch.Bip. 287 Abandoned field, occasional.
Launaea rarifolia (Oliv. & Hiern) L. Boulos 29 Abandoned field, occasional.
Sonchus dregeanus DC. L304, 684 Abandoned field, occasional.
S. oleraceus L. L261 Abandoned field, occasional.
Lactuca capensis Thunb. 88 Abandoned field, occasional.
Crepis hypochaeridea (DC.) Thell. 104, 171, 840 Abandoned field, occasional.

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AN ANNOTATED SYSTEMATIC CHECK LIST OF THE ANGIOSPERMAE OF THE WORCESTER VELD RESERVE

MARIA C. OLIVIER

(Department of Botany, University of Port Elizabeth)

ABSTRACT

The vegetation of the Worcester Veld Reserve is briefly discussed. The 273 species recorded are listed in a systematic check list. Of the 48 families recorded, the Compositae (54 spp.), Liliaceae (37 spp.), Crassulaceae (20 spp.), Gramineae (19 spp.), Mesembryanthemaceae (19 spp.) and Iridaceae (18 spp.) are best represented. The genus *Crassula* is represented by 17 species.

UITTREKSEL

'N GEANNOTEEERDE SISTEMATIESE KONTROLELYS VAN DIE ANGIOSPERMAE
VAN DIE WORCESTERSE VELDRESERVAAT

Die plantegroei van die Worcesterse Veldreservaat word kortliks bespreek. Die 273 spesies wat aangeteken is, word weergegee in 'n sistematiese kontrolelyst. Van die 48 families wat aangeteken is, is die volgende die beste verteenwoordig: Compositae (54 spp.), Liliaceae (37 spp.), Crassulaceae (20 spp.), Gramineae (19 spp.), Mesembryanthemaceae (19 spp.) en Iridaceae (18 spp.). Die genus *Crassula* word verteenwoordig deur 17 spesies.

INTRODUCTION

The Worcester Veld Reserve is situated approximately one kilometer northeast of the town of Worcester, at S 33° 39' and E 19° 27'. The area was proclaimed a nature reserve in 1935 and is administered by the Department of Agricultural Technical Services.

It is essential to have a reasonable knowledge of the species occurring within a protected area. This survey was undertaken as few data were available on the Worcester Veld Reserve. The study was restricted to the approximately 75 ha of natural vegetation north of the municipal canal as the area for the greater part south of the canal had been divided into experimental plots (Fig. 1). In 1973 the area east of the broken line was also cleared for experimental purposes.

METHODS

During the period 1961-1964 the area was visited at regular intervals and specimens were collected in triplicate. One set was sent to the National Herbarium, Botanical Research Institute, Pretoria for identification. One set is housed in the Government Herbarium, Botanical Research Unit, Stellenbosch. The third

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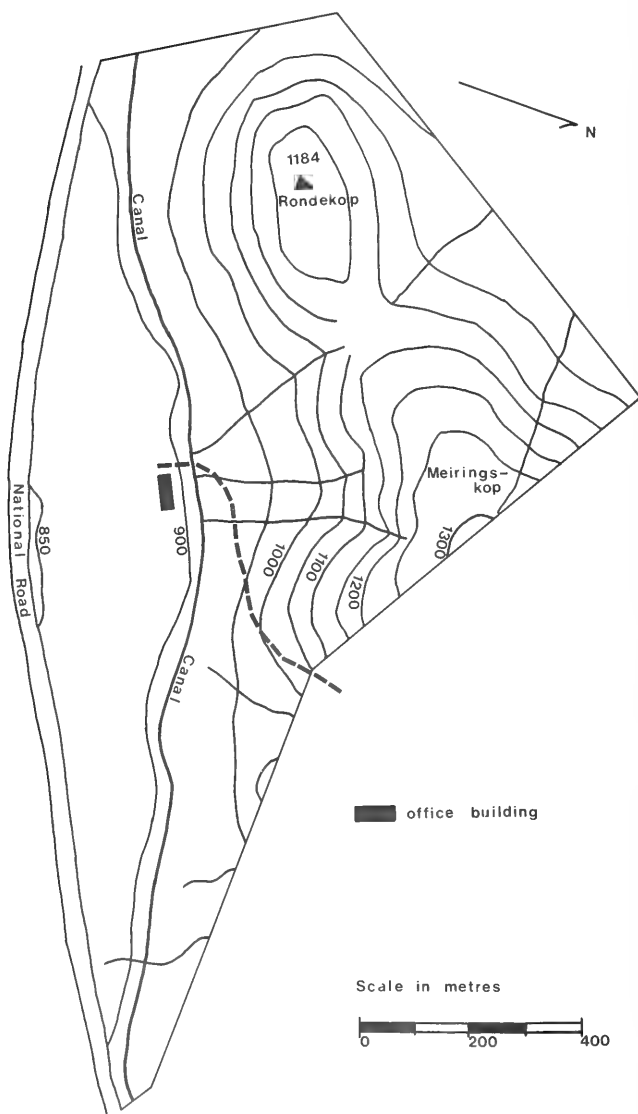


FIG. 1.
Topographic Map of the Worcester Veld Reserve

set was placed in the Worcester Veld Reserve Herbarium. The area was revisited during 1966 and 1977.

Communities were determined by visual assessment. A 1:18 000 topographical map of the relevant area was used, enlarged X15, copied on squared paper, the communities were plotted and the map was then reduced.

Flowering periods were recorded as well as the presence or absence of species in the different communities. Abundance was estimated on a five-point scale: rare, uncommon, fairly common, common and very common.

RESULTS AND DISCUSSION

Vegetation

The Worcester Veld Reserve forms part of a region commonly known as the Robertson Karoo and is classified by Acocks (1975) under Veld Type 26. The area is semi-arid receiving most of its rain during winter. The vegetation consists mainly of shrubs of which a large number are succulents. The plants occur in two strata, the upper stratum seldom exceeding one metre. A tree layer is absent. The four tree species, *Euclea undulata*, *Dodonaea viscosa* var. *angustifolia*, *Rhus incisa* and *R. undulata* which grow in the area are stunted and occur mostly as shrubs. A herb layer consisting of annuals and geophytes is found here and there after the winter rains.

Two well-defined communities can be distinguished:

1. *Euphorbia mauritanica*-community and 2. *Pteronia paniculata*-community (Fig. 2).

1. *Euphorbia mauritanica*-community

This community occurs over the whole area, mostly as distinct circular stands on the soils of the so-called "kraaltjies" (Van der Merwe, 1962), with a diameter varying from 20 to 50 metres. The soil is deep and soft with a considerable amount of organic material, the pH varying between 7,4 and 8,4. The vegetation is dense and the dominant species are: *Euphorbia mauritanica*, *E. burmannii*, *Galenia africana*, *Pteronia incana* and *Ruschia caroli*.

2. *Pteronia paniculata*-community

This community occupies the area outside the *Euphorbia mauritanica* stands. It occurs on poorly developed stony soils with very little organic material, the pH varying from 3,9 to 4,9. The vegetation is open and *Pteronia paniculata* and *Ruschia caroli* are the dominant species. On the hill tops two fynbos elements, *Restio gaudichaudianus* and *Passerina obtusifolia* are found.

Flora

There are 48 families, 153 genera and 273 species of angiosperms in the Worcester Veld Reserve. An analysis of the families indicates that nine (18,75 %)

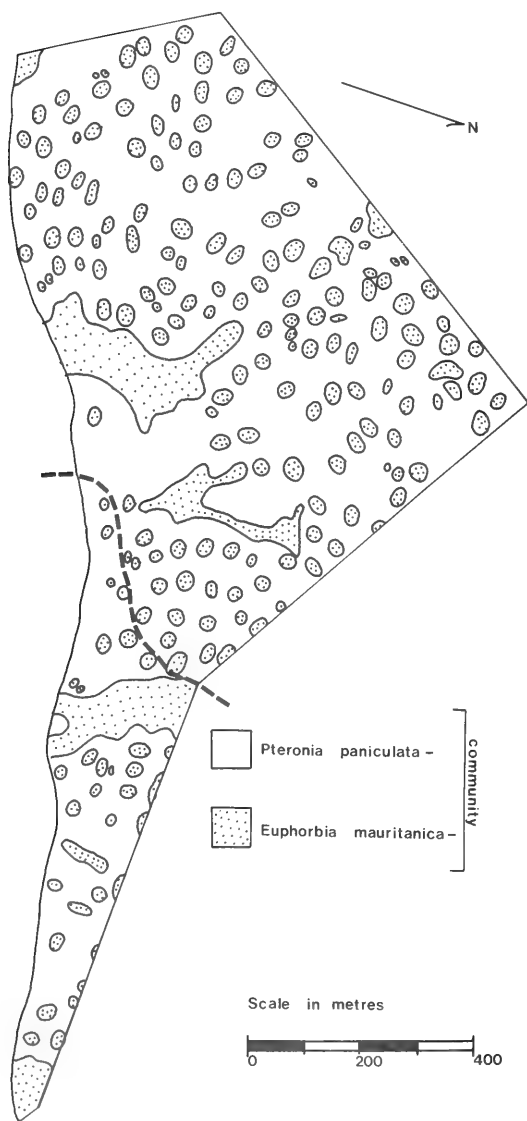


FIG. 2.
Vegetation Map of the Worcester Veld Reserve

are monocotyledons and 39 (81,25 %) are dicotyledons. The monocotyledons are represented by 88 (32,23 %) and the dicotyledons by 185 (67,77 %) species. There are 14 (29,17 %) families whose species contribute more than 1,5 % of the total number of species and these are listed in order of numerical importance in Table 1. Twenty (41,67 %) families are represented by one species only, nine (18,75 %) families are represented by two species, four (8,33 %) by three species and one (2,08 %) by four species.

Phenology

An analysis of the flowering periods of the different species is given in Table 2 and Fig. 3.

TABLE 1.

Synopsis of the families whose species comprise more than 1,5 % of the total number listed in order of numerical importance, together with the number of genera in each family.

Family	No. of species	No. of species expressed as a % of total	No. of genera	No. of genera expressed as a % of total
Compositae	54	19,78	24	15,69
Liliaceae	37	13,55	16	10,46
Crassulaceae	20	7,33	3	1,96
Gramineae	19	6,96	13	8,50
Mesembryanthemaceae ..	19	6,96	11	7,19
Iridaceae	18	6,59	11	7,19
Aizoaceae	8	2,93	4	2,61
Geraniaceae	8	2,93	2	1,31
Leguminosae	7	2,56	6	3,92
Orchidaceae	6	2,20	3	1,96
Asclepiadaceae	6	2,20	6	3,92
Oxalidaceae	6	2,20	1	0,65
Scrophulariaceae	6	2,20	5	3,27
Umbelliferae	5	1,83	4	2,61

TABLE 2.

Relationship between the percentage of species flowering and the months of the year.

	Months	Species	
		Number	% of Total
	1	13	4,76
	2	13	4,76
	3	27	9,89
	4	19	6,96
	5	19	6,96
	6	35	12,82
	7	59	21,61
	8	108	39,56
	9	138	50,55
	10	62	22,71
	11	37	13,55
	12	21	7,69

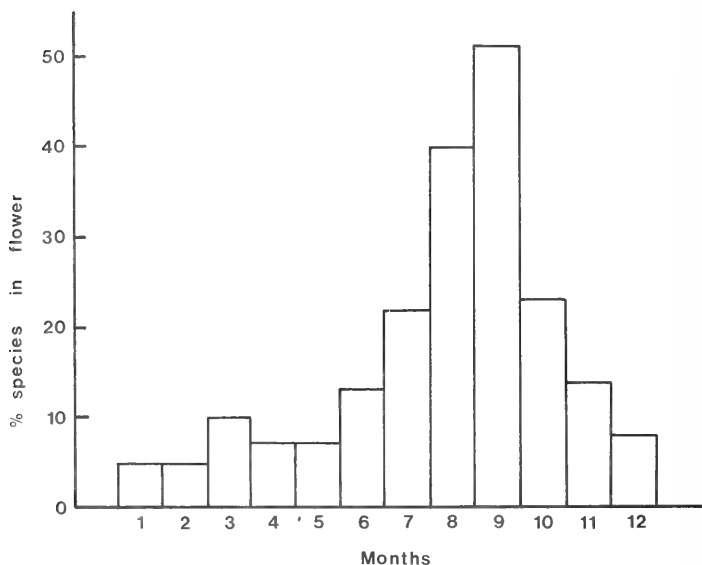


FIG. 3.

Histogram showing the relationship between the percentage of species flowering and the months of the year.

SYSTEMATIC LIST

The systematic list is arranged according to Dyer (1975, 1976). (The numbers following the species refer to the author's collecting number, fl. = flowering period, E.m. = *Euphorbia mauritanica*-community and P.p. = *Pteronia paniculata*-community).

DICOTYLEDONAE

SANTALACEAE

Thesium aggregatum A. W. Hill 53, fl. 1-12, P.p. fairly common

HYDNORACEAE

Hydnora africana Thunb. 294, fl. 9, E.m. parasitic on *Euphorbia mauritanica* and *E. burmannii*, fairly common.

POLYGONACEAE

Rumex cordatus Desf. 45, fl. 6-8, P.p. southern aspect of Meiringskop, uncommon.

CHENOPODIACEAE

Chenopodium murale L. 182, fl. 9, E.m. annual, uncommon.

Exomis microphylla (Thunb.) Aellen var. *axyrioides* (Fenzl) Aellen 209, fl. 12, P.p. one plant observed north of office building, locality destroyed 1973.

- Atriplex semibaccata* R.Br. 252, fl. 1–12, P.p. & E.m. fairly common.
Manochlamys albicans (Ait.) Aellen 34, fl. 8–9, P.p. & E.m. fairly common.

AIZOACEAE

- Limeum aethiopicum* Burm.f. subsp. *aethiopicum* 208, fl. 9–12, E.m. northern slope of Rondekop, rare.
Pharnaceum aurantium (DC.) Druce 100, fl. 8–9, P.p. northern aspect, fairly common.
Galenia africana L. 146, fl. 10, P.p. & E.m. very common in E.m.
G. fruticosa (L.f.) Sond. 170, fl. 10, E.m. uncommon, on Rondekop.
Tetragonia arbuscula Fenzl 115, fl. 9–10, P.p. & E.m. fairly common.
T. echinata Ait. 180, fl. 10, E.m. uncommon.
T. robusta Fenzl 125, fl. 8–9, E.m. southern aspect, uncommon.
T. saligna Fenzl 21, fl. 6–9, P.p. & E.m. fairly common.

MESEMBRYANTHEMACEAE

- Conophytum odoratum* (N.E.Br.) N.E.Br. 94, fl. 5–6, P.p. northern aspect, rocky outcrops, fairly common.
Delosperma pageanum (L.Bol.) L.Bol. 41, fl. 6–9, P.p. & E.m. fairly common.
Drosanthemum brevifolium (Ait.) Schwant. 246, fl. 12, P.p. & E.m. eastern part of reserve, uncommon, locality destroyed 1973.
D. calycinum (Haw.) Schwant. 160, fl. 9–10, E.m. southern aspect, fairly common.
D. lique (N.E.Br.) Schwant. 244, fl. 6–9, P.p. & E.m. common.
D. speciosum (Haw.) Schwant. 164, fl. 10–11, P.p. fairly common.
D. striatum (Haw.) Schwant. 91, fl. 8, P.p. southern aspect of Meiringskop, uncommon.
Lampranthus haworthii (Don) N.E.Br. 161, fl. 8–9, P.p. & E.m. common.
L. sp. cf. L. versicolor Haw. 287, fl. 9, P.p. southern aspect, uncommon.
Leipoldtia jacobseniana Schwant. 214, fl. 9, P.p. & E.m. northern aspect, common.
Mesembryanthemum magniflorum Eckl. & Zeyh. 226, fl. 11, E.m. annual, uncommon.
Nycteranthus blandus (L.Bol.) Schwant. 179, fl. 10–11, P.p. & E.m. fairly common.
N. sp. 200, fl. 10–11, P.p. fairly common.
Prenia pallens (Ait.) N.E.Br. 191, fl. 10, E.m. northern aspect of Meiringskop, uncommon.
Psilocaulon rogersiae L.Bol. 202, fl. 10–11, E.m. common.
Ruschia caroli (L.Bol.) Schwant. 215, fl. 9, P.p. & E.m. very common.
R. hamatilis L.Bol. 245, fl. 9, P.p. southern aspect of Meiringskop, uncommon.
R. multiflora (Haw.) Schwant. 193, fl. 10–11, P.p. & E.m. uncommon.
Sceletium joubertii L.Bol. 110, fl. 9, P.p. low lying area north of office building, locality destroyed 1973.

PORTULACACEAE

- Anacampseros telephiastrum* DC. 192, fl. 11, P.p. fairly common.
A. sp. 242, fl. 11, P.p. uncommon.

ILLECEBRACEAE

- Pollichia campestris* Ait. 249, fl. 2, P.p. northern aspect of Rondekop, rare.

MENISPERMACEAE

- Cissampelos torulosa* E.Mey. ex Harv. 43, fl. 7, P.p. & E.m. common.

FUMARIACEAE

- Cysticapnos vesicarius* (L.) Fedde 90, fl. 8–9, E.m. southern aspect, annual, fairly common.

CRUCIFERAE

- Heliphilla crithmifolia* Willd. 75, fl. 8-9, P.p. & E.m. uncommon.
H. suavisissima Burch. ex DC. 87, fl. 9, P.p. & E.m. fairly common.

CRASSULACEAE

- Cotyledon orbiculata* L. 184, fl. 10-3, P.p. & E.m. common.
C. paniculata L.f. 237, fl. 11-12, P.p. & E.m. common in E.m.
Crassula arborescens (Mill.) Willd. subsp. *arborescens* 238, fl. 10-11, P.p. & E.m. northern aspect, uncommon.
C. atropurpurea (Haw.) Dietr. var. *rubella* (Compton) Toelken 167, fl. 10-11, P.p. & E.m. common in P.p.
C. bergioides Harv. 289, fl. 9, P.p. annual, rare.
C. campestris (Eckl. & Zeyh.) Endl. ex Walp. subsp. *campestris* 176, fl. 9, P.p. southern aspect, annual, rare.
C. capitiella Thunb. subsp. *thyrsiflora* (Thunb.) Toelken 239, fl. 3-4, E.m. uncommon.
C. expansa Dryand. in Ait. subsp. *expansa* 185, fl. 1-12, P.p. & E.m. uncommon.
C. muricata Thunb. 240, fl. 10, P.p. uncommon.
C. muscosa L. 201, fl. 9-11, P.p. & E.m. common.
C. nudicaulis L. var. *nudicaulis* 177, fl. 8-10, P.p. & E.m. common in P.p.
C. oblanceolata Schönl. & Bak.f. 175, fl. 9, E.m. annual, fairly common.
C. rupestris Thunb. subsp. *rupestris* 26, fl. 7-9, P.p. & E.m. northern aspect, common.
C. saxifraga Harv. 2, fl. 4, P.p. southern aspect of Meiringskop, uncommon.
C. subaphylla (Eckl. & Zeyh.) Harv. 166, fl. 10, P.p. & E.m. common.
C. subulata L. 213, fl. 12-3, P.p. uncommon.
C. tetragona L. subsp. *tetragona* 224, fl. 3-7, P.p. & E.m. fairly common.
C. tomentosa Thunb. var. *tomentosa* 205, fl. 11, E.m. uncommon.
C. umbellata Jacq. 80, fl. 8-9, P.p. & E.m. southern aspect, uncommon.
Adromischus mammillaris (L.f.) Lem. ex Berger 212, fl. 1-3, P.p. & E.m. common in P.p.

LEGUMINOSAE

- Lebeckia cytisoides* Thunb. 101, fl. 8-10, P.p. southern aspect of Rondekop, on area that was burnt in 1938, common.
Aspalathus candicans Ait. 158, fl. 9-10, P.p. uncommon.
A. lactea Thunb. subsp. *breviloba* R. Dahlgr. 228, fl. 9-3, P.p. fairly common.
Melolobium microphyllum Eckl. & Zeyh. 229, fl. 8, E.m. low lying area above office building, locality destroyed 1973.
Indigofera sessilifolia DC. 72, fl. 7-9, P.p. & E.m. fairly common.
Psoralea candicans Eckl. & Zeyh. 207, fl. 10, P.p. southern aspect of Meiringskop, rare.
Sutherlandia frutescens R.Br. 157, fl. 8-9, P.p. & E.m. uncommon.

GERANIACEAE

- Erodium cicutarium* (L.) L'Hérit. ex Ait. 272, fl. 8-9, E.m. southern aspect, annual, uncommon.
Pelargonium alchemilloides (L.) L'Hérit. ex Ait. 58, fl. 10-11, P.p. & E.m. southern aspect, uncommon.
P. alternans Wendl. 173, fl. 4-10, P.p. northern aspect, common.
P. carnosum (L.) Ait. 126, fl. 9, P.p. southern aspect, rare.
P. lobatum (L.) Ait. 71, fl. 8-9, P.p. & E.m. southern aspect, fairly common.
P. longifolium (Burm.f.) Jacq. 13, fl. 12-2, P.p. & E.m. uncommon.
P. tripartitum Willd. 147, fl. 9, E.m. rare.
P. sp. 259, fl. 4, P.p. & E.m. south-western aspect of Rondekop, rare.

OXALIDACEAE

- Oxalis* sp. cf. *O. amblyosepala* Schltr. 264, fl. 7-9, P.p. & E.m. fairly common.
O. depressa Eckl. & Zeyh. 265, fl. 7-9, P.p. on Rondekop, uncommon.
O. pes-caprae L. 263, fl. 6-9, P.p. & E.m. fairly common.
O. sp. (sub. sect. *Pardales*) 262, fl. 6-7, P.p. southern aspect, uncommon.
O. sp. 257, fl. 5-8, E.m. southern aspect, uncommon.
O. sp. 258, fl. 5-8, P.p. southern aspect, uncommon.

ZYGOPHYLLACEAE

- Zygophyllum fulvum* L. 18, fl. 7-8, P.p. & E.m. southern aspect, fairly common.

POLYGALACEAE

- Polygala affinis* DC. 81, fl. 7, P.p. southern aspect, rare.
Nylandtia spinosa (L.) Dumort. 86, fl. 7, P.p. northern aspect, rare.

EUPHORBIACEAE

- Euphorbia burmannii* E.Mey. ex Boiss. 92, fl. 8-9, P.p. & E.m. very common in E.m.
E. mauritanica L. 17, fl. 6-9, P.p. & E.m. very common in E.m.
E. nesemannii R.A.Dyer 225, fl. 5-6, P.p. northern aspect of Rondekop, localised.

ANACARDIACEAE

- Rhus incisa* L.f. 49, fl. 8, P.p. & E.m. common.
R. undulata Jacq. 216, fl. 5-6, P.p. & E.m. southern aspect, uncommon.

SAPINDACEAE

- Dodonaea viscosa* Jacq. var. *angustifolia* Benth. 44, fl. 7-8, P.p. uncommon.

MALVACEAE

- Anisodonteia triloba* (Thunb.) Bates 16, fl. 5-10, P.p. & E.m. southern aspect, uncommon.

STERCULIACEAE

- Hermannia candicans* Ait. 128, fl. 7-9, P.p. & E.m. fairly common.
H. desertorum Eckl. & Zeyh. 85, fl. 8, P.p. & E.m. fairly common.

THYMELAEACEAE

- Struthiola leptantha* Bol. 23, fl. 7-8, P.p. northern aspect, localised.
Passerina obtusifolia Thoday 118, fl. 9, P.p. on Rondekop & Meiringskop, common.

UMBELLIFERAE

- Arctopus echinatus* L. 61, fl. 7-8, P.p. southern aspect of Meiringskop, localised.
Torilis arvensis (Huds.) Link 121, fl. 9, E.m. southern aspect, annual, fairly common.
Rhyticarpus difformis (L.) Benth. & Hook. 210, fl. 11, P.p. & E.m. fairly common.
R. sp. 56, fl. 11, P.p. southern aspect, uncommon.
Chamarea capensis (Thunb.) Eckl. & Zeyh. 93, fl. 3-4, P.p. low lying areas, fairly common.

EBENACEAE

- Euclea undulata* Thunb. var. *undulata* 183, fl. 12, P.p. & E.m. more common on northern aspect.

GENTIANACEAE

- Sebaea exacoides* (L.) Schinz 154, fl. 8-9, P.p. annual, southern aspect, uncommon.

APOCYNACEAE

Carissa haematocarpa (Eckl.) A.DC. 293, fl. 11, P.p. northern aspect of Meiringskop, rare.

ASCLEPIADACEAE

Microlooma sagittatum (L.) R.Br. 5, fl. 6–10, P.p. & E.m. southern aspect, uncommon.
Asclepias cancellata Burm. f. 27, fl. 4–9, P.p. northern aspect, uncommon.
Sarcostemma viminale (L.) R.Br. 6, fl. 2, P.p. & E.m. northern aspect, fairly common.
Duvalia radiata Haw. 218, fl. 3, P.p. & E.m. southern aspect, uncommon.
Caralluma sp. 217, fl. 6, P.p. & E.m. fairly common.
Orbea variegata (L.) Haw. (= *Stapelia variegata* L.) 211, fl. 3, P.p. & E.m. uncommon.

BORAGINACEAE

Lobostemon echiodos Lehm. 74, fl. 6–10, P.p. southern aspect of Rondekop, uncommon.

LABIATAE

Ballota africana (L.) Benth. 169, fl. 9–10, P.p. & E.m. southern aspect, uncommon.
Stachys aethiopica L. 35, fl. 7–10, E.m. southern aspect, fairly common.

SOLANACEAE

Lycium arenicolum Miers 47, fl. 5–9, P.p. & E.m. common in E.m.
L. austrinum Miers 89, fl. 7, E.m. rare.
Solanum tomentosum L. 206, fl. 11, E.m. northern aspect of Meiringskop, rare.

SCROPHULARIACEAE

Diascia nana Diels 103, fl. 9, P.p. annual, uncommon.
D. parviflora Benth. 25, fl. 8–9, P.p. & E.m. southern aspect, annual, fairly common.
Hemimeris montana L.f. 24, fl. 8–9, P.p. & E.m. southern aspect, annual, fairly common.
Sutera glabrata (Benth.) Kuntze 33, fl. 6–9, P.p. & E.m. uncommon.
Polycarena pubescens Benth. 137, fl. 8–9, P.p. southern aspect, annual, fairly common.
Hyobanche sanguinea L. 292, fl. 8, P.p. northern aspect, uncommon.

SELAGINACEAE

Selago fruticulosa Rolfe 267, fl. 7–8, P.p. low lying areas, fairly common.
S. sp. cf. S. spinea Link 32, fl. 8–9, P.p. uncommon.

PLANTAGINACEAE

Plantago cafra Decne 291, fl. 8, P.p. annual, rare.

RUBIACEAE

Anthospermum aethiopicum L. 37, fl. 7–9, P.p. & E.m. on Rondekop.
Galium asperum Thunb. 152, fl. 10, E.m. fairly common.
G. spurium L. 152a, fl. 10, E.m. fairly common.

CUCURBITACEAE

Kedrostis nana (Lam.) Cogn. var. *zeyheri* (Schrad.) A.Meeuse 243, fl. 2, E.m. rare.

CAMPANULACEAE

Lichtfootia albens Spreng. ex A.DC. 153, fl. 7–9, P.p. & E.m. southern aspect, common.

LOBELIACEAE

Cyphia digitata (Thunb.) Willd. 7, fl. 8–9, P.p. & E.m. uncommon.

COMPOSITAE

- Pteronia fasciculata* L.f. 57, fl. 11, P.p. common on Meiringskop.
P. incana (Burm.) DC. 123, fl. 9–10, P.p. & E.m. very common in E.m.
P. paniculata Thunb. 14, fl. 12–1, P.p. & E.m. very common especially in P.p.
Felicia filifolia (Vent.) Burt Davy subsp. *filifolia* 22, fl. 7–8, P.p. & E.m. common.
Chrysocoma coma-aurea L. 20, fl. 7–10, P.p. & E.m. common.
C. tenuifolia Berg. 55, fl. 11, P.p. & E.m. uncommon.
Gnaphalium declinatum L.f. 280, fl. 9–11, P.p. & E.m. uncommon.
G. undulatum L. 253, fl. 3, P.p. & E.m. uncommon.
Helichrysum capillaceum (Thunb.) Less. 155, fl. 9, P.p. & E.m. annual, uncommon.
H. ericaefolium Less. 236, fl. 11–1, P.p. & E.m. uncommon.
H. hebelepis DC. 198, fl. 9, P.p. rare.
H. rosum (Berg.) Less. 190, fl. 10–11, P.p. & E.m. fairly common.
H. rutilans (L.) Less. 296, fl. 9, P.p. annual, rare.
Leontonyx squarrosus (L.) DC. 281, fl. 10, P.p. annual, rare.
Elytropappus gnaphaloides (L.) Levyns 222, fl. 3, P.p. rare.
E. rhinocerotis (L.f.) Less. 223, fl. 4–5, P.p. & E.m. common.
Relhania genistifolia (L.) L'Hérit. 274, fl. 9–10, P.p. & E.m. uncommon.
R. sessiliflora (L.f.) Thunb. 133, fl. 9, P.p. & E.m. annual, uncommon.
R. squarrosa (L.) L'Hérit. 111, fl. 9, P.p. & E.m. common in P.p.
Leyssera gnaphaloides (Burm.f.) L. 285, fl. 9, P.p. & E.m. southern aspect, rare.
Inula graveolens (L.) Desf. 235, fl. 3–4, P.p. & E.m. annual, uncommon.
Eriocephalus africanus L. 42, fl. 7, P.p. & E.m. fairly common.
E. ericoides (L.f.) Druce 220, fl. 7–8, P.p. & E.m. northern aspect, uncommon.
Athanasia trifurcata L. 195, fl. 11, P.p. & E.m. uncommon.
Cotula sororia DC. 132, fl. 8–9, P.p. southern aspect, annual, uncommon.
Pentzia globifera (Thunb.) Hutch. 159, fl. 10–11, E.m. annual, uncommon.
P. incana (Thunb.) Kuntze 116, fl. 7–10, P.p. & E.m. fairly common.
Cineraria lobata L'Hérit. 174, fl. 9–10, E.m. southern aspect, uncommon.
C. saxifraga DC. 178, fl. 9, P.p. southern aspect, annual, uncommon.
Senecio acaulis (DC.) Sch.Bip. 189, fl. 10, P.p. southern aspect, uncommon.
S. aizoides (DC.) Sch.Bip. 219, fl. 6, P.p. on Meiringskop, uncommon.
S. burchellii DC. 73, fl. 6–11, P.p. & E.m. fairly common.
S. corymbiferus DC. 19, fl. 8, P.p. & E.m. common.
S. junceus Harv. 233, fl. 3–4, P.p. & E.m. fairly common.
S. radicans (L.f.) Sch.Bip. 40, fl. 7–10, P.p. & E.m. common.
S. rosmarinifolius L.f. 221, fl. 12, P.p. & E.m. southern aspect, rare.
S. sophioides DC. 134, fl. 8–9, P.p. & E.m. annual, fairly common.
Euryops linearis Harv. 70, fl. 8, P.p. on Meiringskop, fairly common.
E. tenuissimus (L.) DC. 188, fl. 10, P.p. & E.m. southern aspect, fairly common.
Othonna amplexifolia DC. 46, fl. 6–7, P.p. southern aspect, uncommon.
O. sp. cf. O. arbuscula (DC.) Sch.Bip. 261, fl. 3–4, P.p. & E.m. common on Meiringskop.
O. carnosa Less. 38, fl. 5–9, P.p. uncommon.
O. gymnodiscus (DC.) Sch.Bip. 39, fl. 7–8, P.p. southern aspect, uncommon.
O. lobata Schltr. 29, fl. 6–7, P.p. & E.m. uncommon.
Osteospermum calendulaceum L.f. 270, fl. 9–10, E.m. annual, uncommon.
O. clandestinum (Less.) Norl. 99, fl. 8–9, P.p. & E.m. annual, uncommon.
O. scariosum DC. 84, fl. 8, P.p. southern aspect, rare.
O. sinuatum (DC.) Norl. 48, fl. 7–9, P.p. & E.m. fairly common.
Ursinia anthemoides (L.) Poir. 98, fl. 8–9, P.p. annual, uncommon.
U. pilifera (Berg.) Poir. 142, fl. 9–10, P.p. fairly common.
Arctotis arctotoides (L.f.) O. Hoffm. 113, fl. 8–9, E.m. annual, uncommon.
Gazania krebsiana Less. 284, fl. 9, P.p. uncommon.
Hirpicium integrifolium (Thunb.) Less. 112, fl. 9–10, P.p. & E.m. fairly common.
Sonchus oleraceus L. 199, fl. 9–10, P.p. & E.m. annual, uncommon.

MONOCOTYLEDONAE

GRAMINEAE

- Hyparrhenia hirta* (L.) Stapf 279, fl. 8–12, P.p. northern aspect of Rondekop.
Ehrharta calycina J.E.Sm. 50, fl. 8–9, P.p. & E.m. common.
E. delicatula Stapf 120, fl. 8–9, P.p. & E.m. annual, fairly common.
E. erecta Lam. 83, fl. 8–9, E.m. southern aspect, fairly common.
E. longiflora J.E.Sm. 150, fl. 9, P.p. & E.m. southern aspect, annual, fairly common.
E. triandra Nees 148, fl. 8–9, P.p. & E.m. annual, fairly common.
E. villosa Schult.f. 165, fl. 10, P.p. & E.m. southern aspect, fairly common.
Phalaris minor Retz. 278, fl. 9–10, E.m. northern aspect, annual, fairly common.
Merxmuellera arundinacea (Berg.) Conert 168, fl. 9, P.p. one clone observed on western slope of Rondekop.
M. stricta (Schrad.) Conert 297, fl. 9–10, P.p. fairly common.
Karooochloa curva (Nees) Conert & Turpe 149, fl. 9, P.p. & E.m. uncommon.
Pentastichis airoides (Nees) Stapf 130, pl. 8–9, P.p. & E.m. annual, fairly common.
Eragrostis curvula (Schrad.) Nees 127, fl. 7–9, P.p. northern aspect, localised.
Cynodon dactylon (L.) Pers. 241, fl. 11–5, P.p. & E.m. fairly common.
Briza minor L. 194, fl. 9, P.p. annual, southern aspect, uncommon.
Schismus inermis (Stapf) C.E.Hubb. 172, fl. 8–9, E.m. annual, fairly common.
Poa vivipara (L.) Willd. 271, fl. 8–9, P.p. southern aspect, uncommon.
Bromus japonicus Thunb. 131, fl. 8–9, P.p. & E.m. southern aspect, annual, common.
Hordeum murinum L. 151, fl. 9–10, P.p. & E.m. southern aspect, annual, fairly common.

CYPERACEAE

- Ficinia ramosissima* Kunth 31, fl. 8–9, P.p. & E.m. uncommon.
F. striata (Thunb.) Kunth 82, fl. 7–9, P.p. fairly common, localised, northern aspect.
Scirpus setaceus L. 136, fl. 8, P.p. annual, uncommon.

RESTIONACEAE

- Restio gaudichaudianus* Kunth 12, fl. 4–8, P.p. on Rondekop and Meiringskop.

LILIACEAE

- Androcymbium capense* (L.) Druce 36, fl. 7–8, P.p. fairly common.
Wurmbea spicata (Burm.) Dur. & Schinz 197, fl. 10, P.p. southern aspect, uncommon.
Bulbinella setosa (Willd.) Dur. & Schinz 1, fl. 7, P.p. southern aspect, uncommon.
B. triquetra Kunth 269, fl. 8, P.p. southern aspect of Meiringskop, uncommon.
Bulbine alooides (L.) Willd. 97, fl. 8–9, P.p. & E.m. southern aspect, uncommon.
B. caespitosa Bak. 88, fl. 8, P.p. & E.m. southern aspect.
B. filifolia Bak. 203, fl. 11–2, P.p. & E.m. fairly common.
Trachyandra falcata (L.f.) Kunth 144, fl. 9, E.m. on Rondekop, rare.
T. jacquiniana (Roem. & Schult.) Oberm. 104, fl. 8–9, P.p. & E.m. fairly common.
Eriosperrum capense (L.) Thunb. 63, fl. 3, P.p. southern aspect, fairly common.
E. cordiforme Salter 69, fl. 3, P.p. fairly common.
E. lanceaeifolium Jacq. 66, fl. 3, P.p. fairly common.
E. proliferum Bak. 96, fl. 3, P.p. southern aspect, rare.
Aloe microstigma Salm-Dyck 95, fl. 6–8, P.p. & E.m. especially abundant on northern aspect.
Haworthia margaritifera (L.) Haw. 124, fl. 12–1, P.p. & E.m. common.
H. setata Haw. 129, fl. 9–10, P.p. northern aspect on rocky outcrops, fairly common.
Tulbaghia alliacea L.f. 3, fl. 3–4, P.p. southern aspect of Meiringskop, uncommon.
Albuca altissima Dryand. 143, fl. 9, E.m. uncommon.
A. canadensis (L.) Leighton 30, fl. 8, P.p. fairly common.
A. spiralis L.f. 141, fl. 9, P.p. low lying areas, fairly common.
Urginea altissima (L.f.) Bak. 67, fl. 12, P.p. & E.m. fairly common.

- Drimys media* Jacq. ex Willd. 250, fl. 3, P.p. & E.m. southern aspect, uncommon.
Ornithogalum dubium Houtt. 186, fl. 10, P.p. southern aspect of Meiringskop, localised.
O. hispidum Hornem. 109, fl. 11–12, P.p. southern aspect, uncommon.
O. nanodes Leighton 251, fl. 3, P.p. southern aspect, rare.
O. pilosum L.f. 140, fl. 10, P.p. & E.m. southern aspect, uncommon.
O. salteri Leighton 60, fl. 9, P.p. & E.m. uncommon.
Lachenalia glaucina Jacq. 105, fl. 8, P.p. northern aspect, rare.
L. pustulata Jacq. 52, fl. 8–9, P.p. & E.m. uncommon.
L. unifolia Jacq. 59, fl. 8–9, P.p. & E.m. southern aspect, uncommon.
Massonia depressa Thunb. ex Houtt. 62, fl. 7, P.p. & E.m. southern aspect, uncommon.
Asparagus asparagoides (L.) Wight 171, fl. 8, E.m. fairly common.
A. capensis L. var. *capensis* 8, fl. 5–6, P.p. & E.m. fairly common.
A. crispus Lam. 4, fl. 6–7, P.p. & E.m. southern aspect, fairly common.
A. mucronatus Jessop 276 & 277, southern aspect of Meiringskop, rare.
A. retrofractus L. 9, fl. 6, E.m. southern aspect, rare.
A. suaveolens Burch. 10, fl. 3–4, E.m. common.

AMARYLLIDACEAE

- Amanthus tigrinus* Jacq. 68, fl. 3–4, E.m. southern aspect, uncommon.
Nerine humilis (Jacq.) Herb. 11, fl. 4, E.m. southern aspect of Meiringskop, uncommon.

HYPOXIDACEAE

- Spiloxene serrata* (Thunb.) Garside 15, fl. 5–8, P.p. & E.m. fairly common.

TECOPHILAEACEAE

- Cyanella hyacinthoides* L. 64, fl. 9, P.p. uncommon.

IRIDACEAE

- Moraea algoensis* Goldbl. 138, fl. 8–9, P.p. southern aspect, fairly common.
M. gawleri Spreng. 106, fl. 8–9, P.p. southern aspect, fairly common.
M. unguiculata Ker-Gawl. 163, fl. 9–10, P.p. & E.m. fairly common.
M. viscaria (L.f.) Ker-Gawl. 162, fl. 9, P.p. southern aspect, uncommon.
Gynandris setifolia (L.f.) Fost. 290, fl. 9, E.m. southern aspect, rare.
G. simulans Bak. 117, fl. 9, P.p. southern aspect, rare.
Ferraria divaricata Sw. subsp. *australis* de Vos 187, fl. 9, P.p. & E.m. uncommon.
Hexaglottis lewisiae Goldbl. (= *H. flexuosa* (L.f.) Sweet) 204, fl. 11, P.p. southern aspect, rare.
Homeria collina (Thunb.) Vent. 135, fl. 9, P.p. southern aspect, uncommon.
Hesperantha bracteolata Fost. 283, fl. 8–9, P.p. southern aspect, fairly common.
H. falcata (L.f.) Ker-Gawl. 78, fl. 8–9, P.p. & E.m. southern aspect, fairly common.
H. radiata (Jacq.) Ker-Gawl. 122, fl. 8–9, P.p. southern aspect, fairly common.
Ixia latifolia Delaroche var. *angustifolia* Lewis 28, fl. 7–8, P.p. southern aspect, fairly common.
Babiana patula N.E. Br. 76, fl. 8, P.p. rare.
Gladiolus sculleyi Bak. (= *Gladiolus venustus* Lewis) 107, fl. 9, P.p. rare.
Lapeirousia pyramidalis (Lam.) Goldbl. (= *L. fissifolia* (Jacq.) Ker-Gawl.) 102, fl. 9, P.p. low lying areas, uncommon.
Anomatheca fistulosa (Spreng. ex Klatt) Goldbl. (= *Lapeirousia fistulosa* (Spreng. ex Klatt) Bak.) 77, fl. 8, P.p. & E.m. uncommon.
Freesia refracta Klatt 51, fl. 8, P.p. fairly common.

ORCHIDACEAE

- Holothrix mundii* Sond. 79, fl. 7, P.p. southern aspect, rare.
H. secunda (Thunb.) Reichb.f. 295, fl. 9, P.p. southern aspect, rare.
H. villosa Lindl. 181, fl. 9, P.p. southern aspect, rare.

Satyrium erectum Schwartz 108, fl. 9, P.p. low lying areas, fairly common.

S. odorum Sond. 139, fl. 9, P.p. southern aspect, rare.

Disperis bolusiana Schltr. 266, fl. 8, P.p. southern aspect, rare.

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DIE ANATOMIE EN ULTRASTRUKTUUR VAN DIE EKSTRAFLORALE NEKTARKLIERE VAN *DIOSCOREA SYLVATICA* ECKL. EN DIE SAMESTELLING VAN DIE NEKTAR

I. VON TEICHMAN UND LOGISCHEN en P. J. ROBERTSE

(Departement Plantkunde, Universiteit van Pretoria)

UITTREKSEL

Die ekstraflorale nektarkliere by *Dioscorea sylvatica* is van die oppervlakkige soort en word op verskeie dele van die plant aangetref. Die kliere aan die abaksiale kant van die blaarskyf wat sigbare nektardruppeltjies uitskei word beskryf. 'n Skede wat subepidermaal in oorsprong is, skei die klierweefsel van die blaarmesofil. Die klierweefsel is epidermaal in oorsprong. Die perifere laag klierselle verskil van die res deurdat onder andere veral die radiale selwande 'n besondere sterk lipied impregnering het. Die impregnering is ook tot 'n mindere mate by die aktief uitskeidende klierweefsel waargeneem. Die sitoplasmaryke klierselle bevat besonder baie mitochondria met opvallende groot kristae. Goed gedifferensieerde diktiosome is daarenteen afwesig. Die oppervlakkige klierselle het 'n opvallend goed ontwikkelde ER. In die nektar kom daar blykbaar verskeie suikers voor, waaronder fruktose, glukose en sukrose. 'n Aantal aminosure kom ook in lae konsentrasies daarin voor.

ABSTRACT

THE ANATOMY AND ULTRASTRUCTURE OF THE EXTRAFLORAL NECTARIES OF *DIOSCOREA SYLVATICA* ECKL. AND THE COMPOSITION OF THE NECTAR

The extrafloral nectaries of *Dioscorea sylvatica* are of the superficial type and occur in various parts of the plant. The glands on the abaxial side of the leaf blade, which secrete visible droplets of nectar, are described. A sheath which is derived from the hypodermis separates the glandular tissue from the leaf mesophyll. The glandular tissue is derived from the epidermis. The peripheral layer of glandular cells differs from the remainder in that, amongst other things, especially the radial walls are heavily impregnated with lipids. This impregnation also occurs but to a lesser extent in the actively secreting glandular cells. The glandular cells which are rich in cytoplasmic components have an exceptionally large number of mitochondria with well-developed cristae. Well-differentiated dictyosomes are absent however. The superficial glandular cells have a markedly well-developed ER. Various sugars, including fructose, glucose and sucrose occur in the nectar. A number of amino acids occur in the nectar in low concentration.

1. INLEIDING

Reeds in 1888 vermeld Correns waarnemings van Kunth, Bokorny en Delpino in verband met die ekstraflorale nektarkliere ("extra-nuptiale Nectarien" soos hy dit noem) op die blare van verskeie *Dioscorea*-spesies. Die Suid-Afrikaanse spesies wat ter sprake was, is waarskynlik *D. elephantipes* en *D. sylvatica* ("Testudinaria *Elephantipes* und *T. montana*"). Correns sien vir die eerste keer

ook kliere op die stingels en blaarstele en gee 'n goeie, volledige beskrywing van die ontogenie en anatomie van die kliere.

Böhmker (1917) het hoofsaaklik die inhoudstowwe van nektarkliere in die algemeen ondersoek terwyl Winkler (1925) die nektarsekresie by "*Testudinaria elephantipes*" meer noukeuring bestudeer het. Orr (1923 en 1926) verwys na vroeëre waarnemings en beskryf vir die eerste keer die gelobde diepgeleë "internal" ekstraflorale nektarkliere in die blare van *D. macroua*, dit is *D. sansibaren-sis* (Burkill, 1960). In dié kliere, wat hy onderskei van die "superficial" of oppervlakkige soort wat onder andere by *D. sylvatica* voorkom, vind hy Gram positiewe bakterieë wat hy as stikstofbinders beskryf.

In sy bydrae tot die kennis van die ekstraflorale nektarkliere by die Angiospermae maak Zimmermann (1932) onderskeid tussen "gestaltete" en "gestaltlose" nektarkliere. By *Dioscorea sylvatica* kom eersgenoemde tipe, naamlik "strukturele" kliere voor, wat meestal makroskopies sigbaar is, 'n bepaalde vorm aanneem, en anatomies gedifferensieerd is. Dié outeur noem ook dat, slegs ses families van die Monocotyledoneae ekstraflorale nektarkliere besit, en dat hulle meestal wortelstokke of soortgelyke stoororgane het en nie uitgesproke higrofiete is nie.

Schnepf (1969) wys daarop hoe moeilik omgrensbaar die begrippe sekresies en ekskresies in die geval van nektarsekresies is. By *D. sylvatica* is die klierselle vir die uitskeiding van nectar gespesialiseer. Ekskresieselle daarenteen sou die produkte in hulle self opberg. Ons beskou die suikerbevattende oplossing, of "nektar" volgens Schnepf (1969), wat die ekstraflorale nektarkliere van *D. sylvatica* uitskei, as 'n sekresie. Ayensu (1972) gee min bykomstige inligting oor die ekstraflorale nektarkliere by *Dioscorea*, wat hy ook "honey glands" noem. Dit blyk dat daar oor die funksie en die samestelling van sekresies van hierdie kliere van *Dioscorea*-spesies feitlik nog niks bekend is nie (Hegnauer, 1963) en die doel van hierdie werk was om die kennis in hierdie verband aan te vul.

2. MATERIAAL EN METODES

a. Algemeen

Vir die ondersoek is *D. sylvatica*-plante van vier lokaliteite in die Transvaal gebruik nl. 2628-CA Johannesburg; 2430-DB Pelgrimsrust; 2429-BB Potgietersrus en 2529-AD Witbank.

b. Ligmikroskopiese ondersoek

Die fiksering is in 10 % akroleïen gedoen terwyl die dehidrering volgens Feder en O'Brien (1968) gedoen is. Vir die infiltrasie en inbedding is die monomeer mengsel (Von Teichman und Logischen, 1973a) gebruik. Die vervaardiging van die 2 μ m dik harssneë en die kleuring met perjodiumsuur Schiff se reagens (PAS), toluidienblou (TB) en Soedan-swart is gedoen volgens Von Teichman und Logischen (1973a en b).

c. Elektronmikroskopiese ondersoek

Die materiaal is in 6 % glutaraaldehid in 'n 0,05 M natriumkakodilaatbuffer pH 7,4 gefikseer terwyl 2 % OsO₄ in dieselfde buffer vir die nafiksering aangewend is. Die dehidrering is met etanol en 1,2-propileenoksied gedoen en die inbedding met Spurr se inbedmedium (Spurr, 1969). Die dunsneë is met behulp van glasmesse op 'n Reichert OM U3 ultramikrotroom gemaak. Hulle is eers met 5 % uranielasetaat wat in dubbel gedistilleerde water opgelos is en wat 'n paar druppels 96 % etanol bevat het, en daarna met loodsitraat gekleur (Reynolds, 1963). 'n Phillips EM 301 elektronmikroskoop is vir die verdere bestudering en fotografie gebruik.

d. Chromatografiese ondersoek

Vir die dunlaagchromatografie is mikrokristallyne selluloseplate berei. Butanol : asynsuur : water = 4:1:1 (v/v) is as loopvloeistof gebruik terwyl die kleuring van die koolhidrate en aminosure met anilienfalaat en ninhidrien respektiewelik uitgevoer is.

'n Hewlett Packard 5750 gaschromatograaf is vir die gaschromatografiese ondersoek gebruik. Die konsentrasie van die monster wat in die apparaat gespuut is, was 19,6 mg/cm⁻³ en slegs 1 µl is ingespuut. 'n 3 m lange glaskolom met 'n buitendeursnee van 6 mm, wat gepak was met 3 % OV-17 op Chromosorb W met 'n maasgrootte van 100 tot 120, is gebruik. Die draergas was stikstof. Die volgende temperatuurgegewens was ter sake. Kolomtemperatuur is geprogrammeer met 'n begintemperatuur van 150 °C en 'n eindtemperatuur van 250 °C terwyl die inlaat- en detektor-temperatuur 250 °C en 280 °C respektiewelik was. Die programmeringstempo was 10 °C/min. 'n Vlamionisasiedetektor is gebruik.

In 'n poging om 'n relatief groot hoeveelheid sekreet vir die chemiese ontleding te versamel is elf plante in 'n fitotron by 'n daglengte van 12 uur met 'n dag- en nagtemperatuur van 28 °C en 18 °C onderskeidelik en 'n relatiewe humiditeit van 80 % geplaas.

Die sekresies wat as blink, taai druppeltjies by elke aktiewe klier sigbaar was, is daagliks versamel deur die blaar teen 'n baie skoon voorwerpglasie te druk. Dié sekreet is met gedistilleerde water afgewas en die oplossing ingedamp en gevriesdroog. Sekresies is egter ook direk vanaf die blare met behulp van 'n spuitjie versamel en direk gaschromatografies ontleed.

3. RESULTATE EN BESPREKING

Volgens Ayensu (1972), en eie waarnemings op vars materiaal kom ekstrasflorale nektarkliere op die blare van die volgende Suid-Afrikaanse *Dioscorea*-spesies voor: *D. burchellii*, *D. cotinifolia*, *D. dregeana*, *D. elephantipes*, *D. hemicypta*, *D. mundtii*, *D. quartiniana*, *D. retusa* en *D. sylvatica*.

a. Algemeen

By *Dioscorea sylvatica* word die ekstraflorale nektarkliere op die blaarlaminas en -stele, sowel as die stingels en bloeiasse aangetref. Die kliere kom aan die abaksiale kant van die lamina voor en is hoofsaaklik in twee gebiede gekonsentreer nl. op die "voorloperpunt" ("Vorläuferspitz" of "forerunner tip") en op die basale gedeelte van die lamina (Fig. 1). Dié verspreiding is blykbaar redelik algemeen by *Dioscorea*-soorte (Burkill, 1960).

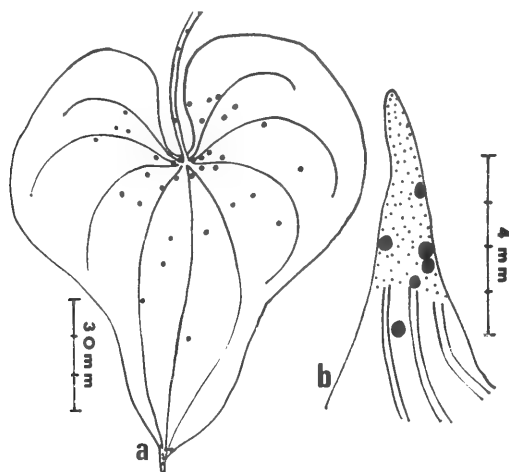


FIG. 1.

Klierverspreiding op die blaar van *D. sylvatica*. 'n Abaksiale aansig a: blaar; b: "voorloperpunt". Die swart kolle verteenwoordig die kliere.

Met die blote oog is hierdie kliere slegs as klein stippeltjies waarneembaar. Onder vergroting is hulle in oppervlakaansig sirkel tot effens ovaalvormig. Blunden *et al.* (1971) gee 'n baie mooi skets van dié aansig. Die lengte daarvan wissel van 0,1 tot 0,45 mm en die breedte van 0,1 tot 0,4 mm. Aktief uitskeidende kliere is blink en groen tot geelgroen van kleur en staan koepelvormig bokant die blaaroppervlak uit, terwyl ou kliere wat hulle afskeidende funksie verloor het, as bruin kratervormige insinkings voorkom.

Die kliere op die blaarstele is meer lank-ovaalvormig en ingesink. Die lengte daarvan wissel van 0,2 tot 0,6 mm en die breedte van 0,1 tot 0,2 mm.

b. Die anatomie van die ekstraflorale nektarkliere

By *Dioscorea sylvatica* is die kliere van die oppervlakkige soort (Orr, 1926) aangesien hulle oppervlakkig in die blaarweefsel geleë is en 'n groot gedeelte van die klier aan die buiteoppervlak blootgestel is. In 'n dwarsdeursnee van die blaar,

is die aktief-uitskeidende klier bikonveks van vorm. Dit word van die mesofil afgegrens deur 'n beskermende skede ("Schutzscheide" volgens Correns, 1888). Die selle van hierdie laag is parenchimaties en van die res van die mesofil selle onderskeibaar omdat hulle kleiner is (Fig. 2 en 3) as laasgenoemde selle, langer meristematies bly en dig teenmekaar sluit. In ouer kliere het die selle effens dikker sellulose wande. Dit is in ooreenstemming met Correns (1888) se waarnemings. Zimmermann (1932) vind onder andere by *Acacia dealbata* kliere met soortgelyke skedes waar die radiaalgestrekte selle egter gelignifiseerde selwande toon, terwyl by ander soorte verkurkte selwande in die skede voorkom.

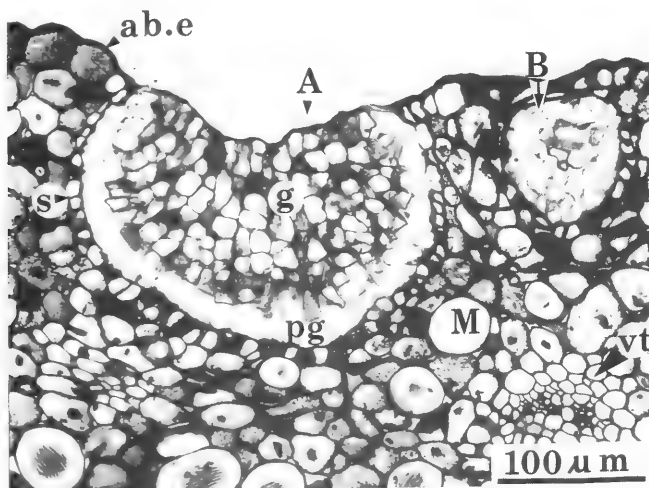


FIG. 2.

'n Dwarsdeursnee van volwasse, aktiewe klier. A: 'n mediane sneë; B: net aan die kant raakgesny *ab. e*: abaksiale epidermis; *g*: klierselle; *M*: mesofil; *pg*: perifere laag klierselle; *s*: skede; *vt*: vaatweefsel. (PAS & TB-kleuring).

Die klierweefsel self bestaan, in 'n dwarsdeursnee van die blaar, uit vierkantige tot radiaalgestrekte sitoplasmaryke selle met klein vakuole en duidelike kerne (Fig. 3). Die klierselle is dikwels in radiale rye gerangskik. Die laag klierselle wat aan die parenchiemskede grens (die binneste laag klierselle) is baie duidelik van die res van die klierselle onderskeibaar omdat hulle inhoude ligter kleur met PAS/TB (Fig. 2 en 3). Die rede daarvoor mag wees dat hulle relatief minder sitoplasma (grootter vakuole) en kleiner kerne besit.

Kleuring van sneë van volwasse kliere met Soedan-swart (Fig. 4), toon dat die klier bedek is met 'n kutikula en dat hoofsaaklik die radiale wande van die perifere klierselle, wat met PAS/TB ligter kleur, met lipiedagtige stowwe

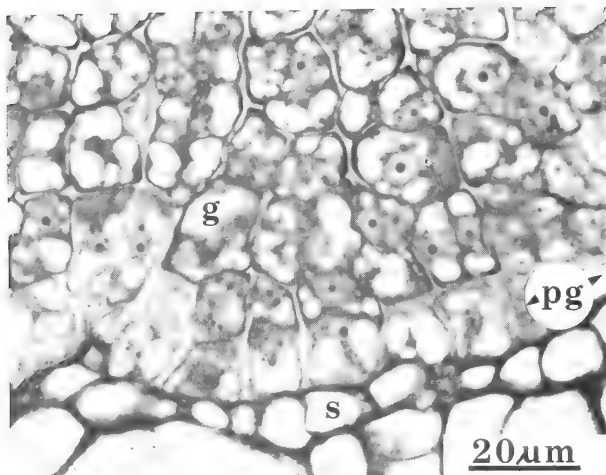


FIG. 3.

'n Dwersdeursnee van 'n gedeelte van 'n volwasse klier. *g*: klierselle; *pg*: periferale laag klierselle; *s*: skede. (PAS & TB-kleuring).

geïmpregneer is. Soos die PAS-kleuring aantoon (Fig. 5a) bevat veral die genoemde radiale wande feitlik geen sellulose nie. Die TB-kleuring van dieselfde sneë toon dat daar blykbaar klein hoeveelhede hemi-sellulose en pektiese stowwe in dié wande voorkom. Met hierdie ondersoek is gevind, dat jong, reeds makroskopies sigbare kliere wat nog *niet* aktief is nie, nog geen lipiede in die selwande besit nie. Jong, aktiewe kliere toon egter wel lipiedimpregnasie. Correns (1888) en Bergmann (1913) meen dat die radiale selwande van die klierselle met suberien geïmpregneer is.

Volgens Schnepf (1969) word die werklike klierselle by baie nektarkliere deur 'n skede waarvan die selwande met kutien of ander stowwe geïmpregneer is, van die res van die plantweefsel afgegrens. 'n Soortgelyke impregnering van elektron-digte, lipiedagtige stof kan in Fig. 5b en 5c waargeneem word. Hierdie verdikte selwande kom veral in die periferale laag klierselle en die aangrensende klierselle voor wat in Fig. 4 'n positiewe reaksie met Soedan-swart toon.

Correns (1888) het blykbaar meestal kliere wat in die "oksels" van die sy-are voorgekom het, ondersoek en daarom is sy opmerking "An jedes Nectarium im Blatte legen sich mehrere Gefässbündel an" verstaanbaar. Vir hierdie ondersoek is klierbevattende gedeeltes van die lamina wat tussen die groter are voorkom, gebruik en in geen geval is vaatweefsel direk langs die kliere gevind nie. Die sneë van die blaarpunte het ook geen vaatweefsel naby die kliere getoon nie en is dus in ooreenstemming met Orr (1926) se bevindings.

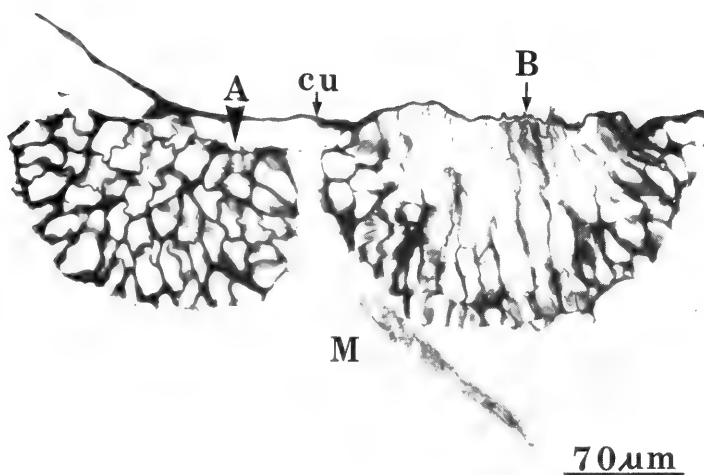


FIG. 4.

'n Dwarsdeursnee van volwasse, aktiewe kliere. A: aan die kant raakgesny, nl deur die perifere laag klierselle; B: 'n meer mediane snee. M: mesofil; cu: kutikula. (Soedanswart-kleuring).

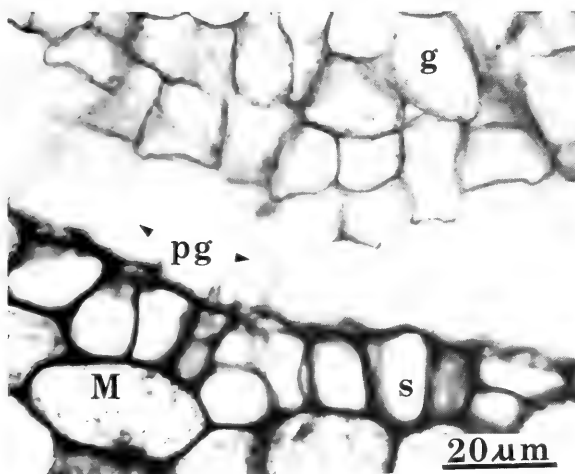


FIG. 5a.

'n Dwarsdeursnee van 'n gedeelte van 'n volwasse klier. g: klierselle; M: mesofil; pg: perifere laag klierselle; s: skede. (L.W. uitsluitlik PAS-kleuring.)

Namate die kliere ouer word en hulle hul uitskeidende funksie verloor, begin veral die buitenste klierselle krimp en radiaal afplat, wat tot gevolg het dat die hele klier 'n kratervormige holte in die blaarweefsel vorm.

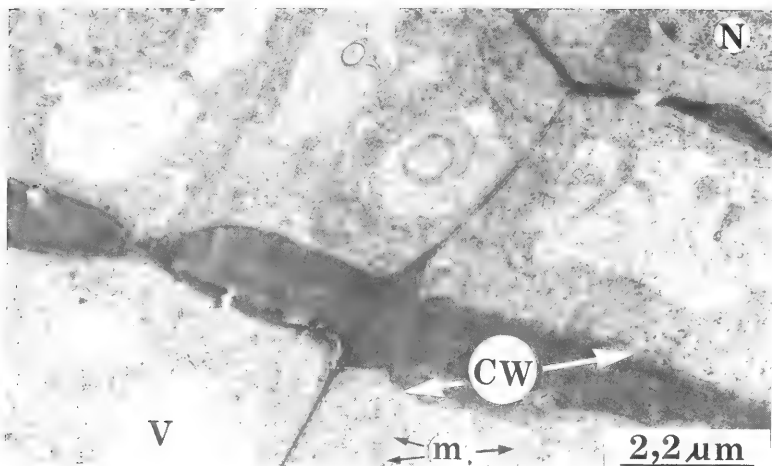


FIG. 5b.

'n Elektronmikrograaf van gedeeltes van klierselle in 'n ouer blaar. CW: radiale selwand; m: mitochondria; N: kern; V: vakuool.

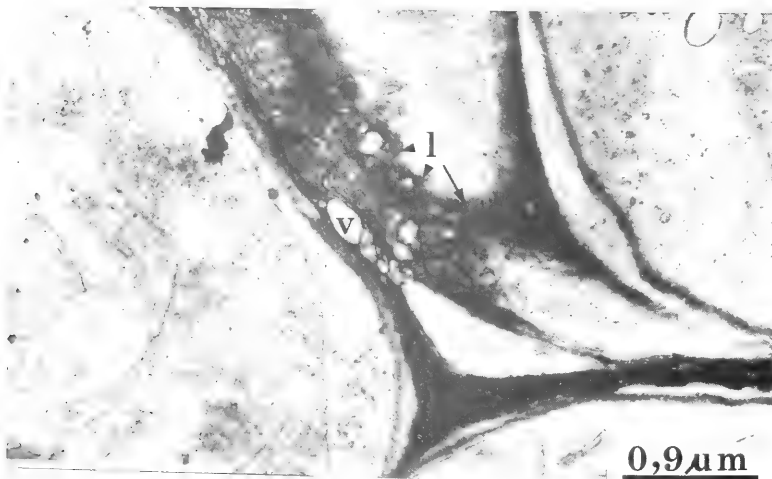


FIG. 5c.

'n Elektronmikrograaf van gedeeltes van klierselle in 'n ouer blaar. l: lipiedagtige stof in die selwand; v: vesikel.

c. Die ontogenie van die kliere

Namate die meristematiese aktiwiteit van die blaarweefsel begin afneem, vind daar 'n basipetale ontwikkeling van ekstraflorale nektarkliere aan die abaksiale kant van die blaar plaas. Die eerste kliere ontwikkel op die "voorloperpunt" en met verloop van tyd vind klierontwikkeling ook meer na die basis van die lamina toe plaas.

Volgens Correns (1888), Bergmann (1913) en Orr (1926) ontstaan die klierweefsel by verskeie *Dioscorea*-soorte uit 'n enkele epidermale sel. In die huidige ondersoek op *D. sylvatica* kon nie met absolute sekerheid vasgestel word of die klierweefsel uit 'n enkele of 'n aantal aangrensende epidermisselle ontstaan nie. Op grond van Fig. 6 en met inagneming van die bogenoemde werkers se bevindings blyk dit egter dat die klierweefsel by *D. sylvatica* waarskynlik ook uit 'n enkele epidermissel ontwikkel. Die epidermissel(le) deel antiklinaal om 'n aantal wigvormige, radiaalgestrekte klierselle te vorm (Fig. 7). Die selle van die skede is egter subepidermaal in oorsprong (Fig. 6), soos ook onder andere deur Correns (1888) aangetoon is.

Terwyl antiklinale delings van die selle van die klierliggaam nog voortdurend plaasvind, begin die klierselle radiaal strek en die selinhoud word meer gevakuoleer. Die selle van die skede begin ook geleidelik vergroot (Fig. 7). Daarna vind periklinale delings van die klierselle plaas (Fig. 8). Deur opeen-

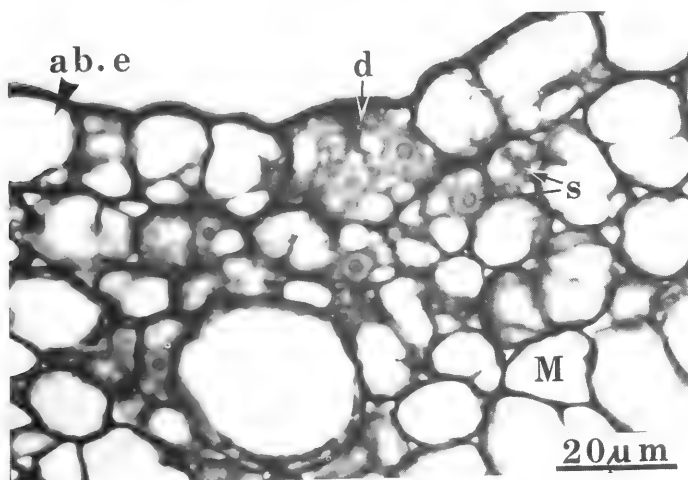


FIG. 6.

'n Dwarsdeursnee van 'n gedeelte van 'n jong *D. sylvatica* blaar. *ab. e*: abaksiale epidermis; *d*: kariokinese is voltooi, maar nie sitokinese nie; *M*: mesofil; *s* meristematiese selle wat oorsprong sal gee aan die skede.

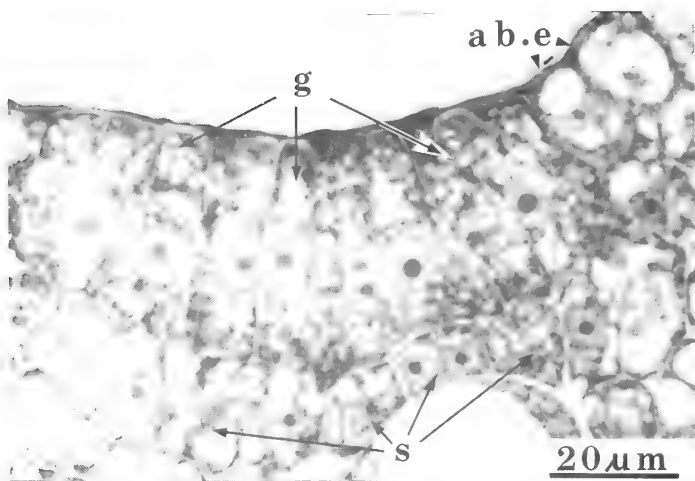


FIG. 7.

'n Dwarsdeursnee van 'n gedeelte van 'n ontwikkelende klier. *ab. e*: abaksiale epidermis; *g*: klierselle; *s*: skedeselle.

volgende antiklinale- en periklinale delings vergroot die klier totdat dit die volwasse stadium bereik (Fig. 2).

d. Die ultrastruktuur van die klierselle

'n Opvallende kenmerk van die dieperliggende klierselle is dat hulle besonder ryk is aan mitochondria (Fig. 9). Dit stem ooreen met bevindings van Wrisher (1962), Schnepf (1969) en Tsekos & Schnepf (1974). Die kristae van die mitochondria is opvallend groot (Fig. 10) soos ook deur Wrisher (1962) by nektarkliere van *Vicia faba* waargeneem is. Die selkerne is relatief groot (Fig. 9).

In die plastiede van die klierselle kom elektrondigte buisvormige strukture voor (Fig. 10). Soortgelyke insluitels van plastiede word ook deur Wrisher (1962) beskryf en volgens genoemde outeur word dit ook deur verskillende ander outeurs vermeld.

Geen goed gedifferensieerde diktiosome is in die klierselle waargeneem nie alhoewel daar in die aangrensende mesofil selle wel diktiosome en goed gedifferensieerde chloroplaste voorkom (Fig. 11). In die oppervlakkige klierselle kom daar 'n opvallende hoeveelheid endoplasmiese retikulum voor. Volgens Schnepf (1969) en Rachmilevitz & Fahn (1973) vind die sekresie waarskynlik deur die endoplasmiese retikulum plaas.

Die spleetvormige openinge in die buitenste selwande van die epidermisselle kan moontlik aan swak fiksering toegeskryf word alhoewel Tsekos & Schnepf

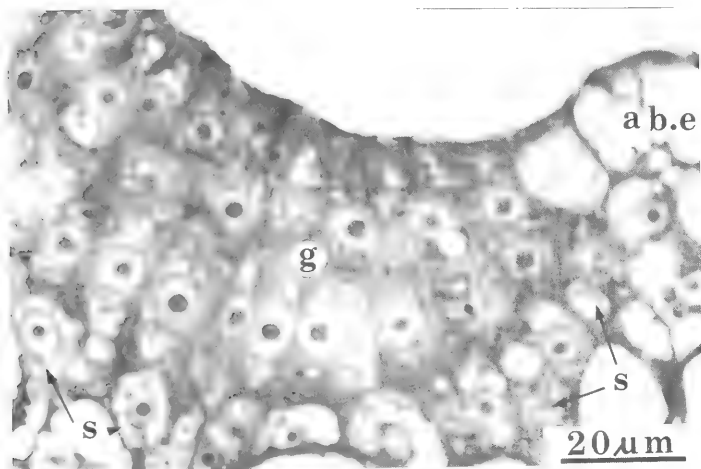


FIG. 8.

'n Dwarsdeursnee van 'n gedeelte van 'n ontwikkelende klier. *ab. e*: abaksiale epidermis; *g*: klierselle; *s*: skedeselle.

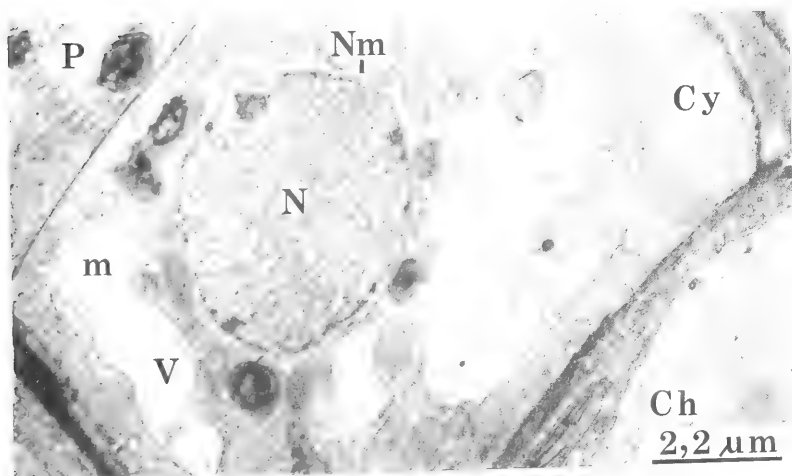


FIG. 9.

'n Elektronmikrograaf van gedeeltes van klierselle in 'n jong blaar. *Ch*: chloroplast; *Cy*: sitoplasma; *m*: mitochondria; *N*: Kern; *Nm*: Kernmembraan; *P*: plastied; *V*: vakuool.

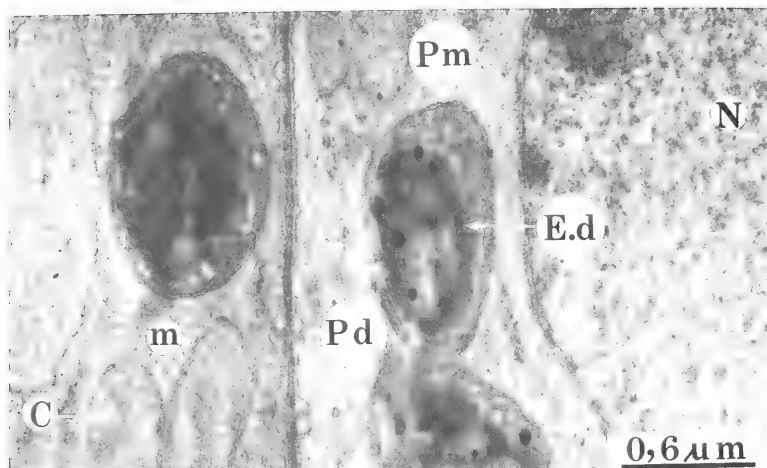


FIG. 10.

'n Elektronmikrograaf wat 'n hoër vergroting van 'n gedeelte van Fig. 9 daarstel. *E. d*: elektrondigte strukture in plastied; *C*: Kristae; *m*: mitochondrion; *N*: Kern; *Pd*: plasmodesma; *Pm*: plastiedmembraan.

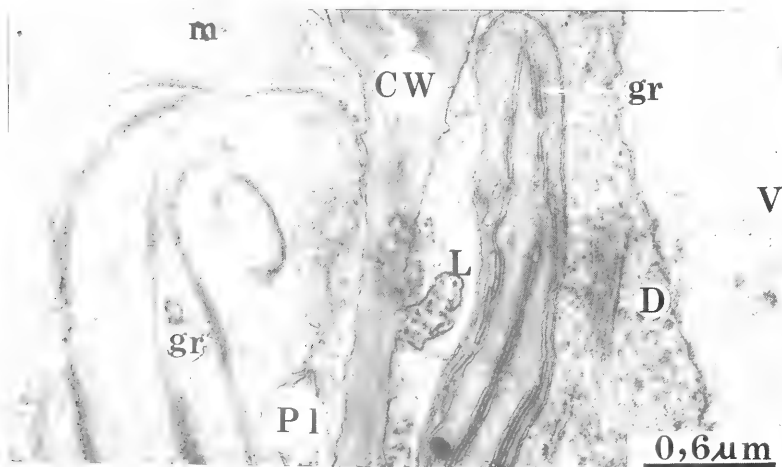


FIG. 11.

'n Elektronmikrograaf van gedeeltes van twee mesofilsete aangrensend aan die klier. *CW*: selwand; *D*: diktiesoom; *gr*: granum in chloroplast; *L*: lomasoom; *m*: mitochondrion; *Pl*: plasmalemma; *V*: vakuool.

(1974) soortgelyke splete wat met uitskeiding in verband staan, in die wande van die klierselle van *Viscaria vulgaris* waargeneem het.

e. Die sekreet van die ekstraflorale nektarkliere

Die sekresies is sigbaar as klein blink druppeltjies. Die plante in die tuin het veral vroeg in die oggend, ongeveer 'n uur na sonopkoms, aktief nektar uitgeskei. 'n Hoër humiditeit, na onlangse reëns, het die uitskeiding opmerklik laat toeneem. Dit het daartoe aanleiding gegee dat 'n aantal knolle in die fitotron geplaas is sodat 'n groter hoeveelheid sekreet oor 'n periode van ongeveer twee maande versamel kon word. Aktiewe kliere het veral op die blare en jong stingels, wat baie aktief groei, voorgekom. Die kliere op die "voorloperpunt" het voor die kliere op die basale lamina begin uitskei. Die relatief onontwikkelde blare (katafile), aan die basis van die stingel, het ook aktiewe kliere bevat. Namate die sytakke ontwikkel en die apikale groei van die hoofstingel vorder, neem die afskeiding van die kliere op die ouer blare af. In die fitotron het die kliere op die blaarstele en bloeiasse ook aktief nektar uitgeskei. Selfs ouer blare wat al begin geel word het, het nog aktiewe kliere bevat.

Volgens die dunlaagchromatografiese ondersoek kom die volgende suikers moontlik in die sekreet voor: arabinose, fruktose,* galaktose,* glukose,* manrose,* melibiose, raffinose, sorbose, sukrose; asook die suiker derivaat glukuron-suur. Blykbaar kom ook die volgende aminosure in lae konsentrasies voor: alanien,* aspartiensuur, glisien,* glutamiensuur,* serien,* treonien, valien* of metionien en waarskynlik ook arginien. Die suikers en aminosure wat met 'n sterretjie gemerk is, kom volgens Hegnauer, 1963 onder andere ook in die slym van *Dioscorea*- en *Tamusknolle* voor.

Uit die gaschromatografiese ondersoek blyk dit dat die samestelling van die sekreet nie konstant is nie. Die variasie is moontlik die gevolg van mikrobiëse werking en/of ensiemwerking (Zimmermann, 1953) nadat die nektar versamel is. Identifisering van die suikers is bemoeilik omdat die suiwer suikers wat as standaardde gebruik is, samestellings van isomere was.

Met inagneming van bogenoemde probleme dui die voorlopige gaschromatografiese resultate daarop dat daar moontlik nege suikerkomponente in die nektar voorkom. Met die tyd ter beskikking kon egter net drie met sekerheid geïdentifiseer word, nl. fruktose, glukose en sukrose. Dit stem onder andere ooreen met die waarnemings van Percival (1961), op die nektar van *Tamus communis* wat naverwant is aan *Dioscorea*, asook onlangse gaschromatografiese nektarontledings op twee *Impatiens* spp. (Elias en Gelband, 1977). Suikers wat blykbaar nie in die uitskeiding van *D. sylvatica* voorkom nie, is arabinose, galaktose, mannose en sorbose (aldus die gaschromatografiese ondersoek).

Ongelukkig geld die stelling van Helder (1958) in verband met nektarkliere vandag nog nl. "little attention has been paid to the physiology of these organs". Daar is relatief min inligting oor (a) die invloed van verskillende faktore op die

proses van nektarproduksie en (b) die meganisme van die nektarsekresie (Helder, 1958 en Schnepf, 1969). Die sekresieproses is onafhanklik van die direkte invloed van baie eksterne faktore. Die algemene fisiologiese toestand van die plant, die stadium van ontwikkeling asook die "suikerstatus" van die plantorgane wat die kliere dra, speel egter 'n betekenisvolle rol in die sekresieproses (Helder, 1958). Correns (1888) se vraag na die betekenis van die nektarkliere vir die biologie van die plant kan nog nie beantwoord word nie.

Die mening van Elias en Gelband (1977) oor die basiese rol van ekstraflorale nektarkliere nl. "current workers accept their role as ant attracting organs" lyk onaanvaarbaar vir *Dioscorea sylvatica*. Miere is naamlik nooit in die natuur op die plante waargeneem nie en outoriteite soos Burkill (1960) meen dat die bestuiwing hoofsaaklik deur nagvlieënde insekte plaasvind. Plante wat tydens hierdie ondersoek in die fitotron gehou is, is wel deur miere besoek.

Volgens Schnepf (1969) kan die nektaruitskeiding die gevolg wees van ondoeltreffende floëmvervoer in meristematie se weefsels waar 'n wanbalans tussen koolhidrate en stikstofverbindinge bestaan.

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**A NOTE ON THE STATUS OF *CARALLUMA ORTHOLOBA* LAVRANOS
(ASCLEPIADACEAE)**

P. V. BRUYNs

ABSTRACT

Reasons are given for considering *C. ortholoba* Lavranos as a synonym of *C. acutiloba* N.E.Br.

UITTREKSEL

'N NOTA OOR DIE STATUS VAN *CARALLUMA ORTHOLOBA* LAVRANOS
(ASCLEPIADACEAE)

Redes word gegee waarom *C. ortholoba* Lavranos as 'n sinoniem van *C. acutiloba* N.E.Br. beskou moet word.

The name *Caralluma ortholoba* was published by Lavranos in volume 38 (2) of this journal where it is regarded as a relative of *C. hottentotorum* N.E.Br. The author was incorrect in allying it with *C. hottentotorum*, however, as it differs from this species in the following respects: (1) The staminal column in *C. hottentotorum* is almost as tall as broad and may be almost spherical with the inner corona lobes rising towards the centre. The illustration [Jl S. Afr. Bot. 38(2): 98 (1972)] shows that this is not the case in *C. ortholoba* in which the column is broad and flat-topped. (2) In *C. hottentotorum* the outer corona-lobes are usually reduced to two very small, often pouch-like structures on the side of the column. Species allied to *C. hottentotorum* in which the outer corona-lobes are as large as those described for *C. ortholoba* [e.g. *C. aurea* Luckh. and some forms of *C. incarnata* (N.E.Br.)] have an entirely different corolla shape to that of *C. ortholoba* and have numerous hairs on the corolla face. The coronal structure of *C. ortholoba* is, however, identical to that of *C. acutiloba*. (3) The illustration in Jl S. Afr. Bot. depicts a bud of *C. ortholoba* as well and this is identical to buds of *C. acutiloba* (which generally have a broad, bowl-shaped base and a narrow cylindrical portion near the tip) and are not similar to those of *C. hottentotorum* in any of its forms.

Lavranos, in his paper (1972), mentions three further distinguishing features: (1) Corolla yellowish with minute irregular purple blotches; (2) Corolla-lobes broadly deltoid, 3 mm long and about as broad; (3) Corolla campanulate.

Flowers of *C. acutiloba* are very variable in colour and this ranges from yellow or yellow with irregular blotches (of various colours) to very dark, purple-black.

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The ratio of corolla-lobe length to breadth in *C. acutiloba* is also very variable and specimens have been observed with lobes from as long as broad at the base to over twice as long as broad at the base.

A "campanulate" corolla similar to that recorded for *C. ortholoba* was observed in plants brought to Cape Town from Taaiboshhoek (the type locality of *C. ortholoba*). However, plants seen subsequently in flower at the same locality (Bruyns 1523, NBG) were *C. acutiloba*.

It is therefore clear that *C. ortholoba* is merely a variant of *C. acutiloba* and the former name must fall into synonymy as follows:

Caralluma acutiloba N.E.Br., in Thistleton-Dyer, Fl. Cap. 4(1): 877 (1909); White and Sloane, The Stapelieae 1:315 (1937). Type: Cape, Little Namaqualand, Templeman in Pillans 8 (BOL). *Caralluma ortholoba* Lavranos in Jl S. Afr. Bot. 38(2): 97 (1972). Type: Cape, Loeriesfontein-3018 (Khamiesberg): Taaiboshhoek (-DD), Lavranos 8227 (PRE).

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NEW SPECIES OF CAPE IRIDACEAE

PETER GOLDBLATT

(*B. A. Krukoff Curator of African Botany, Missouri Botanical Garden, St. Louis, Missouri, U.S.A.*)

ABSTRACT

Gladiolus delpierrei, *Ixia thomasiae* and *Babiana virginea* are new species of Iridaceae-Ixioideae. All three were discovered after 1970 in the southwestern part of the Cape Province, South Africa. Detailed descriptions are followed by discussion of their relationships to other species. Chromosome counts are given for *I. thomasiae* ($2n = 20$) and *B. virginea* ($2n = 14$).

UITTREKSEL

NUWE SPESIES VAN KAAPSE IRIDACEAE

Gladiolus delpierrei, *Ixia thomasiae* en *Babiana virginea* is nuwe spesies van Iridaceae-Ixioideae. Al drie was ontdek na 1970 in die suidwes Kaap-Provinsie, Suid-Afrika. Beskrywings word gevolg deur 'n bespreking van hulle verwantskappe met andere spesies. Chromosoomgetalle vir *I. thomasiae* ($2n = 20$) en *B. virginea* ($2n = 14$) aangegee.

INTRODUCTION

The Iridaceae is an important family in southern Africa in terms of number of species. Centred in the Cape Floristic Region, it occurs throughout southern Africa, with significant concentrations in the Natal and Transvaal Drakensberg as well as the southwestern Cape. It is the fifth largest family in the flora of southern Africa (Goldblatt, 1978) after Compositae, Aizoaceae, Leguminosae and Liliaceae, and consists of some 840 species in 44 genera. The Iridaceae of southern Africa comprise more than 55 % of the estimated total of 1 460 species in the family as a whole (Goldblatt, unpubl.).

The family is well understood at the generic level in Africa, and there are modern revisions for almost half the genera. In spite of this, unknown species continue to come to light, sometimes forgotten amongst the incertae in herbaria, and sometimes discovered for the first time in remote or under-collected parts of southern Africa. The present paper deals with species in the latter category. The new species described here were all discovered since 1970. All belong to genera for which there are good modern revisions so that there is no question that they may have been collected before, and now lie misidentified in some herbarium. Since so many Iridaceae bloom infrequently, and even then have a short flowering period, it is likely that more unknown species will come to light from time to time,

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even in well collected areas as indicated by examples such as those of *Gladiolus lapeirousioides* (Goldblatt, 1971a), *Moraea indecora* (Goldblatt, 1976) and *Moraea loubseri* (Goldblatt, 1977a; 1977b). Not unexpectedly the three species described here all have a very limited distribution, and in fact each is known from only single populations of relatively small size. Extremely localised species such as these are fairly frequent in the predominantly arid southwest part of southern Africa, and especially in the southwestern Cape.

Chromosome counts were made for two of the three species. Root tip squashes were made following pretreatment in 0.003 M hydroxyquinoline for six hours, fixation in Carnoy's solution and hydrolysis in 10% HCl for five minutes. Root tips were stained in lacto-propionic orcein. In both species counts were obtained from corms taken from the type collection.

SPECIES DESCRIPTIONS

BABIANA

***Babiana thomasiae* Goldblatt, sp. nov.**

Cormus ca. 15 mm in diametro, tunicis brunneis, supra extensis. *Caulis* brevis 10–30 mm longus, simplex. *Folia* 8–9, plicata, erecta, ad 300 mm longa, multi-pilosa. *Bractea* exterior ad 80 mm longa, herbacea pilosa; interior 40–45 mm longa. *Flores* 2–4, bilabiati, albi, flavo maculati, odorati: *tubus perianthii* 60–65 mm longus; *tepalum superius* ca. 40 mm longum, erectum; inferiora tria 30–70 mm longa. *Stamina* unilateralia; antherae 9–11 mm longae. *Ovarium* glabrum; rami styli 5 mm longi.

Type: South Africa, Cape, Blomfontein farm, Roggeveld escarpment, between Calvinia and Middelpos, Goldblatt s.n. (MO 2 419 601, holotype; K, NBG, PRE, S, isotypes). (Fig. 1).

Corm about 15 mm in diameter, ovoid, deep seated with tough light brown tunics. *Stem* fairly short, reaching 10–30 mm above ground, simple. *Leaves* 8–9, plicate, ensiform, erect, to 300 mm long, bearing many very fine hairs. *Spikes* 40–60 mm long, 2–4 flowered. *Bracts* lanceolate, heavily pilose, herbaceous, with attenuate brown apex, lowermost 80 mm or longer, upper 20–40 mm; inner bract 40–45 mm similar to outer but minutely bi-apiculate. *Flower* zygomorphic, \pm bilabiate, white with pale yellow markings on lower tepals; sweetly scented; *perianth tube* 60–65 mm long, almost straight, widened very gradually to apex, 2 mm in diameter at base, 6–7 mm at throat; *outer tepals* slightly larger than inner with upper tepal to 40 mm, held apart from others and lower three 30–50 mm long, forming a lip. *Stamens* inserted 6–7 mm below top of perianth tube, unilateral; filaments 15 mm long, anthers 9–11 mm, pale yellow. *Ovary* oblong, glabrous \pm 5 mm long; style reaching to top of anthers with branches 5 mm long, \pm linear with expanded apices. *Capsule* 12–15 mm long, rotund. *Seeds* large, 3 mm in diameter, globose, dark brown. *Chromosome number* $2n = 14$.



FIG. 1.
Morphology and distribution of *Babiana virginea* Goldbl.—whole plant approx. $\times 0.5$;
flower life size.

Flowering time: late September.

Distribution: local on shale outcrops on hills on the Roggeveld escarpment. (Fig. 1).

Babiana virginea was discovered in 1974 by Klas Hiemstra and Margaret Thomas while on a collecting trip from Kirstenbosch Botanic Gardens. Corms brought back to Kirstenbosch flowered in the following year and the plants multiplied to the extent that in 1976 I was able to make the type collection from an ample number of specimens thriving in the Kirstenbosch nursery. Margaret Thomas brought the species to my attention, being sure it was undescribed from her knowledge of *Babiana*, gained while working with G. J. Lewis, who monographed the genus several years ago (Lewis, 1959).

The species is very distinctive in its large white, long-tubed flower, short, rather lax, few flowered spike and softly pilose leaves and bracts. It appears to be most closely related to the long-tubed species of section *Babiana*, in particular to the yellow, shorter tubed *B. vanzylliae* and to the purple, rather narrow leafed *B. sambucina*. Both these species occur in the same general area of the western Karoo in the Calvinia and Sutherland districts. *Babiana virginea* is one of the largest flowered species of the genus, and with a strong and pleasant scent may well be worth horticultural attention. Its chromosome number, $2n = 14$, and karyotype are typical of *Babiana* (Goldblatt, 1971b). With 18 of the 63 species now counted and with no karyotypic variation recorded except for B chromosomes in a few species, the genus can be regarded as fairly well understood cytologically.

SPECIES EXAMINED

South Africa, CAPE—3120 (Williston): West of Blomfontein farm 21,2 m West of Middelpoos, Roggeveld escarpment (CC), Goldblatt s.n. (K, MO, NBG, PRE, S); Hiemstra 601 (NBG).

GLADIOLUS

Gladiolus delpierrei Goldbl. sp. nov.

Planta 0,4–0,45 alta, simplex. *Cormus* globosus, tunicis fibrosis tenuibus. *Folium productum* solitarium, basale, lineare, marginibus et costis incrassatis. *Caulis* folia vaginantia dua ferens. *Spica* secunda, floribus 4–7; bractee herbaceae, exterior 13–17 mm, interior brevior, bifida. *Flores* 4–7, bilabiati, cremei, flavo punctati; *tubus perianthii* 70 mm longus; *tepalum superius* galeatum, 24 mm longum, lateralia extensia, inferiora tria labiata. *Stamina* unilateralia; antherae 6 mm longae. *Stylus* ramosus ad apicem antherarum.

Type: South Africa, Cape, Cedarberg Sneeuberg, Delpierre 456 (NBG). (Fig. 2).

Plants 0,4–0,45 m tall, unbranched. *Corm* globose, with shrunken remains of corms of several previous seasons attached below; tunics of fine fibres extending



M. L. B.

FIG. 2.

Morphology and distribution of *Gladiolus delpierrei* Goldbl.—plant and flower $\times 0.5$.

upwards in a neck. *Produced leaf* solitary, basal, linear, about as long as the stem; 4–5 mm at widest point, with 2 or 3 prominent veins and slightly thickened margins. *Stem* simple, bearing two sheathing leaves; the lower 70–80 mm long, upper 35–40 mm, both free for about 30 mm. *Spike* secund, 4–7 flowered. *Bracts* herbaceous, darker at apex, outer larger, 13–17 mm long, inner smaller and slightly shorter with bifid apex. *Flower* bilabiate, cream coloured, nectar guide at base of the two lower lateral tepals yellow with two red lines; *perianth tube* 7 mm long, widening towards apex; *tepals* unequal, upper arching over the style and stamens, ca 24 mm long, upper laterals outspread, lower laterals reflexed in lower third at nectar guide and forming a lip; lower tepal concealed under lower laterals. *Stamens* unilateral, arcuate; filaments 13 mm long, anthers contiguous, 6 mm long. *Style* slender, arching over the stamens and branching near apex of anthers. *Capsule* and seed not known.

Flowering time: summer, collected only in January.

Distribution: known only from a south-facing slope of Cedarberg Sneeuberg at 1 900 m (Fig. 2).

Gladiolus delpierrei is known from only one site on the upper south slopes of Sneeuberg in the Cedarberg. It grows in typical Cape sandstone soil amongst Restionaceae and in places where summer moisture is available from cloud condensation. The species is named in honour of its collector, Dr Georges Delpierre, Professor of Biochemistry at the University of the Western Cape at Bellville. Dr Delpierre is the co-author of the excellent book on winter-growing *Gladiolus* species of South Africa (Delpierre & du Plessis, 1974) and has extensive knowledge and interests in geophytic Iridaceae and Amaryllidaceae, especially *Gladiolus*.

The rare montane *Gladiolus delpierrei* seems allied to the small group of slender single-leafed species including *G. debilis*, *G. cylindraceus*, and *G. oreocharis*. It would appear most closely related to the latter, also a montane, summer-flowering species which extends from the Hex River Mountains to the Cedarberg. The differences between *G. delpierrei* and *G. oreocharis* are several, in flower, leaf and corm characters. In particular, *G. oreocharis* does not have the conspicuous old corms attached to the corm base so striking in *G. delpierrei*. The stem leaves of *G. oreocharis* have much longer free portions while it also has larger bracts, a much longer perianth tube and has white to pink or mauve flowers.

The discovery of *Gladiolus delpierrei* brings the total number of species of the genus in southern Africa to 104 (Lewis, Obermeyer & Barnard, 1972) of which 99 are endemic. The total number of species of *Gladiolus* in the Cape Floristic Region is now 72.

SPECIES EXAMINED

South Africa, CAPE—3219 (Wuppertal): Cedarberg Sneeuberg, 1900 m (CA), *Delpierre s.n.* (NBG 100743), *Delpierre 456* (NBG).

IXIA

Ixia thomasiae Goldbl. sp. nov.

Planta gracilis, ad 0,8 m alta. *Cormus* ca 20 mm in diametro, ovoideus, tunicis fibrosis crassis. *Caulis* erectus, filamentosus, pauciramosus. *Folia* 3, inferiora dua basales, ad 0,6 m longa, marginibus nervisque incrassatis. *Spica* pendula, bractae membranaceae, atrovenosae, exterior ca 10 mm longa saepe trifurcata; interior 1 mm brevior bifurcata. *Flores* penduli, subrosei; *tubus perianthii* 7 mm longus, infundibuliformis; *tepala* subaequalia, 20-25 mm longa. *Stamina* erecta, symmetrica; antherae 6 mm longae. Stylus ad 15 mm longus, antheras excedens.

Type: South Africa, Cape, Blomfontein farm, Roggeveld escarpment between Calvinia and Middelpos, Goldblatt 4268 (MO, holotype; K, NBG, PRE, S, isotypes). (Fig. 3).

Plants tall and slender, reaching 0,5-0,8 m, usually growing in clumps. *Corm* to 20 mm in diameter, ovoid, tunics coarsely fibrous, outer layers dark brown; extending upward in a neck. *Stem* erect, wiry, usually bearing 2-3 branches. *Leaves* 3, the two lower basal, linear, at least two-thirds the length of the stem, 3-5 mm wide; margins and midrib much enlarged so that two grooves on each surface run the length of the leaf; upper leaf sheathing the stem for half its length with free portion short. *Spike* pendulous bearing up to 10 flowers. *Outer bract* membranous and pale brown above with conspicuous dark veins, ca 10 mm long, obtuse, usually 3-notched at apex, inner bract similar, about 1 mm shorter, and 2-notched. *Flowers* pendulous, pale pink-mauve; *perianth tube* 7 mm long, narrow at base and widening abruptly at the throat; *tepals* subequal, 20-25 mm long, outspread, narrowly elliptical, obtuse. *Stamens* erect, filaments 4-5 mm long, inserted at base of outer tepals, anthers 6 mm, arranged symmetrically around the style. *Style* to 15 mm long filiform; straight, branching above apex of the anthers, branches 1-1,5 mm, expanded apically. *Capsule* about 4 mm long, three-lobed, surface roughly papillate; *seeds* irregularly globose, to 2 mm in diameter, 2-4 per loculus. *Chromosome number* $2n = 20$.

Flowering time: mid-September-October.

Distribution: Roggeveld escarpment between Middelpos and Calvinia in mountain renosterbos—*Danthonia* veld (Fig. 3).

Ixia thomasiae belongs in section *Morphixia* (Lewis, 1964) and is related to the primitive species of this section, especially the smaller flowered *I. marginifolia*, *I. capillaris* and *I. rapunculoides*, and all have in common wiry stems, stellate flowers with a relatively short perianth tube. *Ixia thomasiae* is distinctive in its leaf, unique in *Ixia*, with its thickened margins and midrib and narrow longitudinal grooves. The pendulous inflorescence is also unusual, although encountered in some forms of *Ixia rapunculoides*.

This species is known from one locality only, on the farm Blomfontein on the edge of the Roggeveld escarpment between Middelpos and Calvinia. The plants grow in well-drained stony soil, usually amid tufts of tall danthoniod grasses. In cultivation plants are shorter, and the leaves somewhat broader, suggesting that height and leaf shape in wild plants are to some extent environmental responses. Chromosome number, $2n = 20$ is typical of *Ixia* (Goldblatt, 1971), 12 of the 45 (Lewis, 1962) species now being known cytologically.

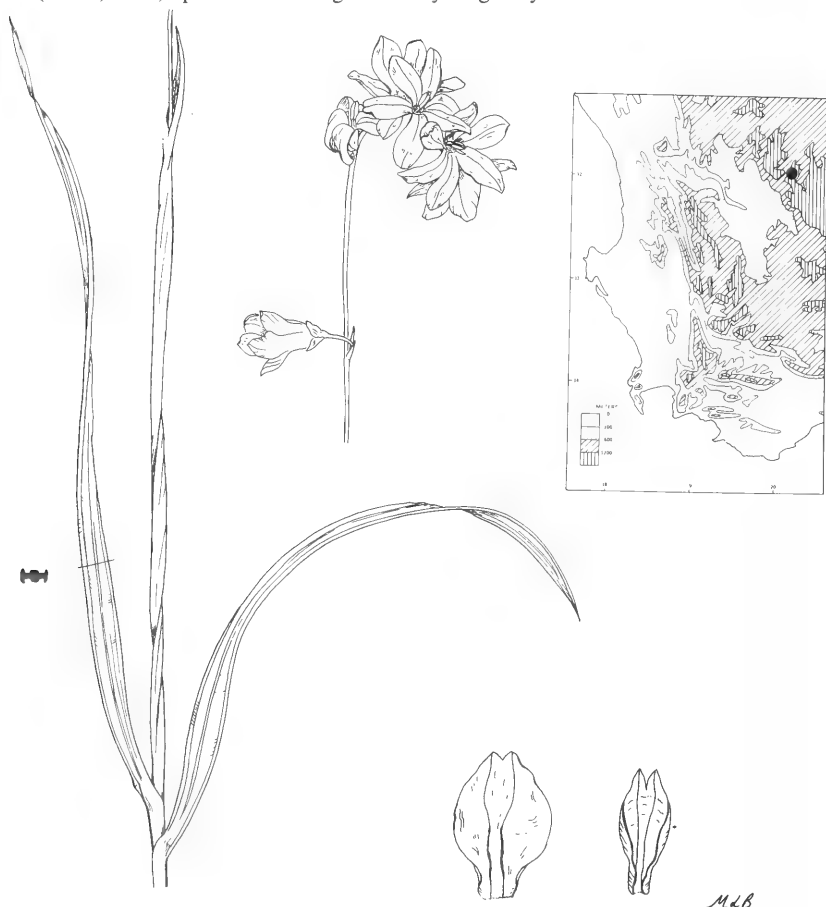


FIG. 3.
Morphology and distribution of *Ixia thomasiæ* Goldbl.—plant and inflorescence $\times 0.5$;
bracts $\times 2$.

Ixia thomasiae is named in honour of Margaret Thomas, an enthusiastic student and grower of the native flora of the southwestern Cape. Her special interest in Iridaceae has frequently been of great assistance to me and other botanists studying the family. She has discovered many rare and unknown species including two described in this paper, *Ixia thomasiae* and *Babiana virginea*, both of which she brought to my notice as worth close attention.

SPECIES EXAMINED

South Africa—3120 (Williston): Blomfontein farm, Roggeveld escarpment w of Middelpoos on Calvinia road (CC), *Thomas s.n.* (NBG 93822), *Thomas s.n.* (in fruit) (NBG 104707), *Goldblatt 4268* (K, MO, NBG, PRE, S).

ACKNOWLEDGEMENTS

This study was supported by Grant DEB 76-19901 from the U.S. National Science Foundation. I thank Margaret Thomas and Georges Delpierre for their co-operation in bringing the species described to my attention and for their assistance in preparing this paper. I also thank Margo Branch for the illustrations.

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BOOK REVIEW

NEW NATURAL PRODUCTS AND PLANT DRUGS WITH PHARMACOLOGICAL, BIOLOGICAL OR THERAPEUTICAL ACTIVITY, edited by H. Wagner and P. Wolff with pp. (170 × 250 mm) xiii, 286 + 152 figures and 35 tables. Berlin, Heidelberg, New York: Springer-Verlag, 1977. DM 67, US\$29.50.

This book covers the proceedings of the First International Congress on Medicinal Plant Research, Section A, held at the University of Munich, Germany from September 6 to 10, 1976. In their preface the editors point out that only some 5% of the approximately 600 000 plant species existing have been investigated chemically or pharmacologically. This book reports on some of the current screening programs undertaken in different parts of the world in the search for compounds from higher plants exhibiting pharmacological activity.

The opening chapter discusses the problems of discovering new drugs from higher plants by pharmacological screening and the next chapter gives an excellent and detailed discussion on natural product screening and evaluation. Other chapters deal with antitumor and cytotoxic agents from plants, antibiotics, alkaloids, terpenoids, saponins, dimeric compounds, Indian medicinal plants, neolignans, natural substances with effects on the liver and the chemical modification of natural substances. Each author making a contribution to this book is an expert and authority, and presents a well rounded review of recent advances occurring in his field.

One of the real strengths of this book is the extensive lists of references; there are over a thousand references and one chapter has 253 while another has 171. Most of the references have the article titles which aids in the retrieval of information. Unfortunately, the references are not treated in the same style throughout; most chapters list their references alphabetically according to author, while a few list them in the order in which they occur in the text, and some references have article titles while others do not.

The real drawback of this volume is its woefully inadequate index. Not all of the chemical compounds discussed in the text appear in the index and then only the starting page of the article is given. To be of any real use to botanists a plant genera and species index should have been included. A general subject index as well as a more complete chemical compound index would have given the book much wider appeal and generally encouraged its use.

The book is written for advanced undergraduates, graduate students, and research workers and any individual who is interested in the isolation of compounds from plants and the testing of these compounds as well as crude plant extracts for pharmacological activity. It is a book for specialists but as such can be highly recommended. Perhaps reading it might stimulate natural products chemists and phytochemists who do not submit their newly isolated compounds for pharmacological testing, to do so in the future.

C. W. GLENNIE

ANNOUNCEMENTS

An International Conference on POLYPLOIDY: BIOLOGICAL RELEVANCE will be held at Washington University (St. Louis) May 24-27, 1979. Cytotaxonomists and cytogeneticists in botany, zoology, and agriculture will find a broad range of lectures and workshops by world-renowned scientists who will discuss plant and animal evolution, and agricultural crops in relation to polyploidy. Anyone desiring a brochure outlining the Conference and a registration form should contact Walter H. Lewis, Department of Biology, Washington University, St. Louis, Missouri 63130, United States of America.

SECOND INTERNATIONAL CONGRESS OF SYSTEMATIC AND EVOLUTIONARY BIOLOGY (ICSEB-II)

The Second International Congress of Systematic and Evolutionary Biology (ICSEB-II) will be held at the University of British Columbia, Vancouver, Canada, 17-24 July 1980.

The Provisional List of Symposia Topics include:

1. Arctic Refugia and the Evolution of Arctic Biota
2. Origins and Evolution of the North Pacific Marine Biota
3. Evolution of Reproductive Strategies
4. Evolutionary Epigenetics
5. Evolution of Community Structure
6. Green Algae and Land Plant Origins
7. Macromolecular Mechanisms in Evolution
8. Allozymes and Evolution
9. Coevolution and Foraging Strategy
10. Evolution of Colonizing Species
11. Rare Species and the Maintenance of Gene Pools
12. Paleobiology of the Pacific Rim

Additional Symposia may be included.

Sessions for contributed papers and for papers in specialized fields, taxonomic as well as methodological will also be organized.

Those interested in receiving an information circular in the spring of 1979, should write to the following: Dr. G. G. E. Scudder, Department of Zoology, the University of British Columbia, 2075 Wesbrook Mall, Vancouver, B.C. V6T 1W5, Canada.

POLLEN MORPHOLOGY OF SOUTH AFRICAN MALVALES: 1. CHARACTERISTICS USEFUL FOR KEYING AND FOR NUMERICAL ANALYSIS

J. COETZEE

(Department of Botany, Potchefstroom University)

H. P. VAN DER SCHIFF

(University of Pretoria)

ABSTRACT

Simple techniques for the preparation of pollen from herbarium material, applicable to

ERRATUM

Vol. 45 (1): 81-89. New species of Cape Iridaceae, by Peter Goldblatt.

An inadvertent transposition of specific epithets occurs on page 82 line 15: *Babiana thomasiae* Goldblatt should read *B. virginea* Goldblatt.

Eenvoudige metodes vir die preparering van stuifmeel van herbariummateriaal, toepaslik by ligmikroskopiese sowel as aftaselektronmikroskopiese ondersoek, word gegee. Kwantitatiewe en kwalitatiewe eienskappe, asook sekere berekende waardes wat bruikbaar is by die konstruksie van 'n sleutel en in numeriese analise van stuifmeel, word genoem. 'n Sinoptiese sleutel tot die spesies van die Suid-Afrikaanse Malvales word gegee.

1. INTRODUCTION

During a study of the pollen of the South African representatives of the Malvales, it became obvious that numerical methods would be necessary for processing of the data obtained. This was necessary because of the size of the data matrix (> 350 species or taxa of lower rank and a total of > 60 characteristics). Another reason for such analysis is the eurycladous nature of the group with pollen size, number and position of apertures and spinulosity all varying within wide limits.

The optical and the scanning electron microscope were used to obtain quantitative and qualitative data from nearly all the local species of this order.

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1. CHARACTERISTICS USEFUL FOR KEYING AND FOR NUMERICAL
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H. P. VAN DER SCHIFF

(University of Pretoria)

ABSTRACT

Simple techniques for the preparation of pollen from herbarium material, applicable to optical and scanning electron microscopy, are given. Quantitative and qualitative characteristics, as well as certain calculated values useful during construction of a key as well as in numerical analysis of pollen, are mentioned. A synoptical key to the South African species of the Malvales, based on pollen morphological characteristics, is given.

UITTREKSEL

**STUIFMEELMORFOLOGIE VAN SUID-AFRIKAANSE MALVALES: 1. KENMERKE
BRUIKBAAR BY SLEUTELVORMING EN NUMERIESE ANALISE**

Eenvoudige metodes vir die preparering van stuifmeel van herbariummateriaal, toepaslik by ligmikroskopiese sowel as aftaselektronmikroskopiese ondersoek, word gegee. Kwantitatiewe en kwalitatiewe eienskappe, asook sekere berekende waardes wat bruikbaar is by die konstruksie van 'n sleutel en in numeriese analise van stuifmeel, word genoem. 'n Sinoptiese sleutel tot die spesies van die Suid-Afrikaanse Malvales word gegee.

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The optical and the scanning electron microscope were used to obtain quantitative and qualitative data from nearly all the local species of this order.

A survey was undertaken to find all possible characteristics which could be used in such an analysis. Due to practical considerations, some of these attributes

could not be determined in all South African representatives of the order. The pollen characteristics used, and presented here, are therefore only those of which the state could be determined in all available specimens.

2. MATERIAL AND METHODS

2.1 General

Owing to the large number of specimens investigated, collection of pollen from specimens in the field was not possible for practical reasons, therefore all pollen was obtained from herbarium specimens filed in the collection of the South African Botanical Research Institute (PRE). Pollen from two or more representatives of each species was studied in most of the cases. In some instances, however, a single specimen only was available and no pollen could be obtained from a limited number of species which were represented only by vegetative herbarium specimens. These species were omitted from this study. Ten pollen grains from each representative were usually studied. Jones & Newell (1948) found that measurements obtained from ten grains usually do not differ appreciably from measurements obtained from as many as 100 grains.

Anthers, the floral column, or, in the case of very small flowers, all the parts of selected flowers were removed from herbarium sheets and prepared for microscopy. Where more than one example of a species or taxon of lower rank is given in the list, the pollen of the sampled specimens differed so much from each other that they had to be entered into the key as separate taxa.

All sampled herbarium sheets were identified by affixing a label stating that pollen samples were removed. Where more than one herbarium sheet of a species was sampled, one was chosen as voucher specimen.

A revision of the Southern African Malvales is in progress for the *Flora of Southern Africa*, but this work has not yet been published. The identity of most of the investigated taxa are according to this revision.

The taxa are arranged according to Hutchinson (1967), but with the genera and species in alphabetical order.

2.2 LIST OF INVESTIGATED TAXA

(Voucher specimens in PRE)

TILIACEAE

Tribe: Enteleaceae

- 1 *Corchorus angolensis* Exell & Mendonca *De Winter & Leistner* 5232
- 2 *C. asplenifolius* Burch. *Codd* 8460
- 3 *C. capsularis* L. *n.c.* 13847

- 4 *Corchorus confusus* Wild Rogers 4863
- 5 *C. junodii* (Schinz) N.E.Br. Edwards 1673
- 6 *C. kirkii* N.E.Br. Louw 794
- 7 *C. longipedunculatus* Mast. Van der Schijff 3054
- 8 *C. merxmuelleri* Wild Giess 1620
- 9 *C. olitorius* L. Melle 14258
- 10 *C. pinnatipartitus* Wild Brueckner 154
- 11 *C. schimperi* Cufod. Meeuse 10645
- 12 *C. sulcatus* Verdoorn Acocks 1445
- 13 *C. tridens* L. Maguire 2427
- 14 *C. trilocularis* L. Mordaunt 1
- 15 *C. velutinus* Wild Acocks 16767

Tribe: Sparmannieae

- 16 *Sparmannia africana* L.f. Thode A750
- 17 *S. ricinocarpa* (Eckl. et Zeyh.) Kuntze Scheepers 585

Tribe: Grewieae

- 18 *Grewia avellana* Hiern De Winter 3765
- 19 *G. bicolor* Juss. Codd 8903
- 20 *G. caffra* Meisn. Ward 646
- 21 *G. falcistipula* K.Schum. De Winter & Wiss 4396
- 22 *G. flava* DC. Acocks 1394
- 23 *G. flavescens* Juss. var. *flavescens* Ross 2003
- 24 *G. flavescens* Juss. var. *olukondae* (Schinz) Wild Story 6486
- 25 *G. hexamita* Burrett Letty 53
- 26 *G. hispida* Harv. Edwards 1025
- 27 *G. inaequilatera* Garcke Acocks 16792
- 28 *G. lasiocarpa* E.Mey. ex Harv. Galpin 3450
- 29 *G. microthyrsa* K.Schum. ex Burrett Ward 3833
- 30 *G. monticola* Sond. Harbor 17031
- 31 *G. occidentalis* L. Sidey 3842
- 32 *G. pachycalyx* K.Schum. Curzon 93
- 33 *G. retinervis* Burrett De Winter 4212
- 34 *G. robusta* Burch. Britten 5505
- 35 *G. rogersii* Burtt Davy & Greenway Galpin 133140
- 36 *G. schinzii* K.Schum. Snitler B97
- 37 *G. subspathulata* N.E.Br. Codd 8904
- 38 *G. sulcata* Mast. Codd & De Winter 5533
- 39 *G. tenax* (Forsk.) Fiori Pole Evans 35927
- 40 *G. vernicosa* Schinz Prosser 1816
- 41 *G. villosa* Willd. Ross 2006

Tribe: Triumfetteae

- 42 *Triumfetta angolensis* Sprague & Hutch. Galpin 2253
- 43 *T. annua* L. forma *annua* Mogg 612
- 44 *T. annua* L. forma *piligera* Sprague & Hutch. Mogg 14988
- 45 *T. pentandra* A.Rich. De Winter & Marais 4608
- 46 *T. pilosa* Roth var. *effusa* (E.Mey. ex Harv.) Wild Acocks 13328
- 47 *T. pilosa* Roth var. *tomentosa* Szyszyl. ex Sprague & Hutch. Codd 5356
- 48 *T. rhomboidea* Jacq. Wells 1241
- 49 *T. sonderi* Fical. & Hiern Theron 1001
- 50 *T. tomentosa* Boj. Boss 36495

- 51 *Triumfetta welwitschii* Mast. var. *hirsuta* (Sprague & Hutch.) Wild Compton 26151
 52 *T. welwitschii* Mast. var. *welwitschii* Meeuse 10270

STERCULIACEAE

Tribe: Dombeyeae

- 53 *Dombeya autumnalis* Verdoorn Verdoorn 2470
 54 *D. cymosa* Harv. Strey 6709
 55 *D. kirkii* Mast. Van der Schijff 3045
 56 *D. kirkii* Mast. Van der Schijff 3810
 57 *D. pulchra* N.E.Br. Clarke 55
 58 *D. rotundifolia* (Hochst.) Planch. var. *rotundifolia* Moll 1905
 59 *D. rotundifolia* (Hochst.) Planch. var. *velutina* Verdoorn Strey 2328
 60 *D. tiliacea* (Endl.) Planch. Strey 6608
 61 *Melhanianthus acuminatus* Mast. De Winter 3788
 62 *M. albicans* Bak.f. Sidey 2473
 63 *M. burchellii* DC. Basson 98
 64 *M. damarana* Harv. Seydel 1382
 65 *M. didyma* Eckl. & Zeyh. Codd & Verdoorn 10175.
 66 *M. didyma* Eckl. & Zeyh. Strey 6146
 67 *M. forbesii* Planch. ex Mast. Mauve 4324
 68 *M. griquensis* Bolus Story 6224
 69 *M. integra* Verdoorn Mauve 4790
 70 *M. prostrata* DC. Codd & Verdoorn 10373
 71 *M. randii* Bak.f. Verdoorn 2501
 72 *M. rehmannii* Szyszyl. Leistner 1998
 73 *M. suluensis* Gerstner Ward 4130
 74 *M. transvaalensis* Szyszyl. Brueckner 246

Tribe: Hermannieae

- 75 *Hermannia abrotanoides* Schrad. Dinter 3498
 76 *H. affinis* K.Schum. Leistner 891
 77 *H. alnifolia* L. Kruger 2
 78 *H. althaeifolia* L. Marsh 1269
 79 *H. althaeoides* Link Thompson 920
 80 *H. amabilis* Marloth ex K.Schum. Goyns 58
 81 *H. amoena* Dinter ex Holzhammer Lavranos 11034
 82 *H. angolensis* K.Schum. De Winter 2847
 83 *H. angularis* Jacq. Mauve 4696
 84 *H. antonii* Verdoorn Codd 2700
 85 *H. argillicola* Dinter ex Holzhammer Leistner 1858
 86 *H. aspera* Wendl. Schlieben 12454
 87 *H. betonicifolia* Eckl. & Zeyh. Louw 365
 88 *H. boraginiflora* Hook. Bolus 10832
 89 *H. brachymalla* K.Schum. Wilms 117
 90 *H. bryoniifolia* Burch. Schweickerdt 2524
 91 *H. burchellii* (Sweet) Verdoorn Acocks 2072
 92 *H. cernua* Thunb. Hanekom 1083
 93 *H. coccocarpa* Kuntze Badenhorst 47
 94 *H. comosa* Burch. Cook (16.9.1967) s.n.
 95 *H. comosa* Burch. Acocks 218
 96 *H. complicata* Engl. Jensen 128
 97 *H. concinnifolia* Verdoorn Foley 11
 98 *H. confusa* Salter Marsh 857

- 99 *Hermannia conglomerata* Eckl. & Zeyh. Jessop 732
- 100 *H. cristata* H.Bol. Strey 7697
- 101 *H. cuneifolia* Jacq. var. *cuneifolia* Acocks 23995
- 102 *H. cuneifolia* Jacq. var. *glabrescens* (Harv.) Verdoorn Hanekom 920
- 103 *H. damarana* Bak.f. Mason & Boshoff 2507
- 104 *H. decipiens* E.Mey. ex Harv. Acocks 20497
- 105 *H. decumbens* Willd. ex Spreng. Esterhuisen 2962
- 106 *H. denudata* L.f. var. *denudata* Zeyher 115
- 107 *H. denudata* L.f. var. *erecta* (N.E.Br.) Burt Davy & Greenw. Galpin 1346
- 108 *H. depressa* N.E.Br. Pegler 923
- 109 *H. desertorum* Eckl. & Zeyh. Hall 3631
- 110 *H. diffusa* L.f. Pillans 8626
- 111 *H. disermifolia* Jacq. Bolus 6671
- 112 *H. disticha* Schrad. Theron 2081
- 113 *H. diversistipula* Presl ex Harv. var. *diversistipula* Smith 3200
- 114 *H. diversistipula* Presl ex Harv. var. *graciliflora* Verdoorn Marsh 935
- 115 *H. elliottiana* (Harv.) K.Schum. Rusch 7967
- 116 *H. engleri* Schinz Story 5593
- 117 *H. erodioides* Kuntze Schlieben 8861
- 118 *H. exilis* Burt Davy Dahlstrand 1937
- 119 *H. filifolia* L.f. var. *filifolia* Acocks 15853
- 120 *H. filifolia* L.f. var. *grandicalyx* Verdoorn Bayliss 208
- 121 *H. flammea* Jacq. Dyer 1417
- 122 *H. flammula* Harv. Muir 2157
- 123 *H. fruticulosa* K.Schum. Acocks 15619
- 124 *H. gariepina* Eckl. & Zeyh. Acocks 16360
- 125 *H. geniculata* Eckl. & Zeyh. Flanagan 88
- 126 *H. gerrardii* Harv. Pentz 304
- 127 *H. glabrata* L.f. Flanagan 1356
- 128 *H. glanduligera* K.Schum. Clarke 51
- 129 *H. glandulosissima* Engl. Dinter 8449
- 130 *H. gracilis* Eckl. & Zeyh. Acocks 12044
- 131 *H. grandiflora* Ait. Shearing 128
- 132 *H. grandifolia* N.E.Br. Malan 17
- 133 *H. grandistipula* K.Schum. Tyson 1115
- 134 *H. grisea* Schinz Verdoorn 2510
- 135 *H. guerkeana* K.Schum. Story 4641
- 136 *H. helianthemum* K.Schum. Barnard 111
- 137 *H. helicoidea* Verdoorn Schlechter 5092
- 138 *H. heterophylla* (Cav.) Thunb. Oliver 3799
- 139 *H. hispidula* Reichb. De Winter & Verdoorn 9059A
- 140 *H. holosericea* Jacq. Mauve 4695
- 141 *H. hyssopifolia* L. Acocks 14637
- 142 *H. incana* Cav. Marsh 575
- 143 *H. involucreta* Cav. Acocks 21116
- 144 *H. jacobaeifolia* R.A.Dyer Acocks 18428
- 145 *H. johanssenii* N.E.Br. Henrici 3475
- 146 *H. joubertiana* Harv. Sidey 1806
- 147 *H. lacera* Fourcade Galpin 87
- 148 *H. lancifolia* Szyszyl. Sutton 697
- 149 *H. lavandulifolia* L. Marsh 816
- 150 *H. leucantha* Schltr. Schlechter 11456
- 151 *H. linearifolia* Harv. Flanagan 1378
- 152 *H. linifolia* Burm.f. Pillans 3950
- 153 *H. linnaeoides* K.Schum. Brueckner 133
- 154 *H. macowanii* (Szyszyl.) Schinz Hanekom 1535

- 155 *Hermannia macra* Schltr. Van Breda 1332
- 156 *H. malvaefolia* N.E.Br. Killick 1722
- 157 *H. marginata* (Turcz.) Pillans Thode A1883
- 158 *H. micrantha* Adamson Esterhuysen 19251
- 159 *H. minimifolia* Holzhammer Dinter 5164
- 160 *H. minutiflora* Engl. Barker 8316
- 161 *H. modesta* (Ehrenb.) Mast. Leistner 1831
- 162 *H. montana* N.E.Br. Rogers 14709
- 163 *H. montana* N.E.Br. Burtt Davy 446
- 164 *H. mucronulata* Turcz. Story 2611
- 165 *H. muirii* Pillans Bayliss 3774
- 166 *H. multiflora* Jacq. Bos 495
- 167 *H. muricata* Eckl. & Zeyh. Schlieben 12440
- 168 *H. oblongifolia* (Harv.) Hochr. Strey 10645
- 169 *H. odorata* Ait. Acocks 15526
- 170 *H. oligosperma* K.Schum. Esterhuysen 15496
- 171 *H. parviflora* (Eckl. & Zeyh.) K.Schum. Barker 10599
- 172 *H. parvula* Burtt Davy Codd 1137
- 173 *H. patellicalyx* Engl. Dinter 6348
- 174 *H. paucifolia* Turcz. Marloth 5634
- 175 *H. pinnata* L. Marsh 1256
- 176 *H. prismatocarpa* E.Mey. ex Harv. Marsh 1263
- 177 *H. pulchella* L.f. Häfstrom & Acocks 941
- 178 *H. pulverata* Andr. Sim 5635
- 179 *H. quartiniana* A.Rich. Story 4568
- 180 *H. rautanenii* Schinz ex K.Schum. Story 5674
- 181 *H. repetenda* Verdoorn De Winter & Verdoorn 9044
- 182 *H. resedifolia* (Burch.) R.A.Dyer Leistner 898
- 183 *H. rigida* Harv. Ellis & Schlieben 12464
- 184 *H. rogersii* Burtt Davy Rogers 18255
- 185 *H. rudis* N.E.Br. Boucher 500
- 186 *H. rugosa* Adamson Thompson 1758
- 187 *H. saccifera* K.Schum. Mauve 4682
- 188 *H. salviifolia* L.f. var. *salviifolia* Taylor 1463
- 189 *H. salviifolia* L.f. var. *oblonga* Harv. Acocks 21112
- 190 *H. sandersoni* Harv. Medley Wood 4653
- 191 *H. scabra* Cav. Rogers 17055
- 192 *H. scordifolia* Jacq. De Winter & Verdoorn 9045
- 193 *H. scordifolia* Jacq. Thompson 1007
- 194 *H. sisymbriifolia* Hochr. Leistner 421
- 195 *H. solaniflora* K.Schum. De Winter & Hardy 8028
- 196 *H. spinosa* E.Mey. ex Harv. Bayliss 2844
- 197 *H. staurostemon* K.Schum. Junod 17526
- 198 *H. stellulata* K.Schum. Leistner 176
- 199 *H. stipulacea* Lehm. Thompson 952
- 200 *H. stricta* (E.Mey. ex Turcz.) Harv. Hardy 2563
- 201 *H. suavis* Presl ex Harv. Olivier 461
- 202 *H. sulcata* Harv. Robbertse 2
- 203 *H. ternifolia* Presl Gillett 4266
- 204 *H. tigrensis* Hochst. in A.Rich. Tölken & Hardy 772
- 205 *H. tomentosa* (Turcz.) Schinz Leistner 1667
- 206 *H. transvaalensis* Schinz Devenish 367
- 207 *H. trifoliata* L. Acocks 22277
- 208 *H. umbratica* Verdoorn Smith 6153
- 209 *H. velutina* DC. Strey 6712
- 210 *H. veronicifolia* (Eckl. & Zeyh.) Hochr. Sidey 1920

- 211 *Hermannia vestita* Thunb. Cannon 132
- 212 *H. viscosa* Hiern De Winter & Leistner 5691
- 213 *H. woodii* Schinz Trauseld 472

Tribe: Sterculieae

- 214 *Cola microcarpa* Brenan Garland 434
- 215 *C. natalensis* Oliv. Ross & Moll 2291
- 216 *Sterculia africana* (Lour.) Fiori Abner A26
- 217 *S. alexandri* Harv. Schönland 1687
- 218 *S. murex* Hemsl. Codd 6145
- 219 *S. quinquiloba* (Garcke) K.Schum. Volk 2903
- 220 *S. rogersii* N.E.Br. Acocks 23354

BOMBACACEAE

- 221 *Adansonia digitata* L. Mills 260

MALVACEAE

Tribe: Malopeae

- 222 *Malope* sp. Sister Tarcisia 68

Tribe: Hibisceae

- 223 *Azanza acutiloba* (Bak.f.) Exell & Mendonca Stewart 218
- 224 *A. garckeana* F.Hoffm. Codd 6908
- 225 *Cienfuegosia digitata* Cav. Strey 3493
- 226 *C. gerrardii* (Harv.) Hochr. Mauve 4444
- 227 *C. hildebrandtii* Garcke Wells 2048
- 228 *Gossypoides kirkii* (Mast.) Hutch. Strey 6817
- 229 *Gossypium anomala* Wawra Merxmüller & Giess 925
- 230 *G. herbaceum* L. var. *africanum* Hutch. & Ghose Thorncroft 74
- 231 *G. triphyllum* (Harv.) Hochr. De Winter 2675
- 232 *Hibiscus aethiopicus* L. var. *ovatus* Harv. Repton 2752
- 233 *H. allenii* Sprague ex Hutch. Killick & Leistner 3356
- 234 *H. altissimus* Hornby Moll 792
- 235 *H. aridus* R.A.Dyer Britten 5899
- 236 *H. articulatus* Hochst. ex A.Rich. Ulbricht 32164
- 237 *H. barbosae* Exell Thorncroft 4989
- 238 *H. caesius* Garcke De Winter 2756
- 239 *H. calyphyllus* Cav. Meeuse 9741
- 240 *H. cannabinus* L. Codd 5926
- 241 *H. castroi* Bak.f. & Exell De Winter & Leistner 5094
- 242 *H. coddii* Exell Smuts & Gillett 4055
- 243 *H. dinteri* Hochr. Strey 2549
- 244 *H. diversifolius* Jacq. subsp. *diversifolius* Acocks 21673
- 245 *H. dongolensis* Del. Edwards 3259
- 246 *H. elliotiae* Harv. Hardy 2038
- 247 *H. engleri* K.Schum. Van Vuuren 1435
- 248 *H. engleri* K.Schum. Theron 2138
- 249 *H. fleckii* Guericke Volk 2352
- 250 *H. fuscus* Garcke Strey 9022
- 251 *H. lobatus* Forsk. Schlieben 9359
- 252 *H. ludwigii* Eckl. & Zeyh. Archibald 4039

- 253 *Hibiscus lunarifolius* Willd. Meeuse 9809
- 254 *H. marlothianus* K.Schum. Werger 190
- 255 *H. mastersianus* Hiern Scheepers 327
- 256 *H. mechowii* Garcke Merxmueller & Giess 1871
- 257 *H. meeusei* Exell Strey 5727
- 258 *H. meyeri* Harv. subsp. *meyeri* Repton 5975
- 259 *H. meyeri* Harv. subsp. *transvaalensis* (Exell) Exell Van der Schijff 982
- 260 *H. micranthus* L. Leistner 2043
- 261 *H. microcarpus* Garcke Guillarmod 4681
- 262 *H. mutatus* N.E.Br. Merxmueller (15.10.1957) s.n.
- 263 *H. palmatus* Forsk. Strey 2625
- 264 *H. pedunculatus* L.f. Strey 6435
- 265 *H. physaloides* Guill. & Perr. Scheepers 633
- 266 *H. platycalyx* Mast. Meeuse & Strey 10459
- 267 *H. praeteritus* R.A.Dyer Strey 3720
- 268 *H. pusillus* Thunb. Dyer 1348
- 269 *H. rhabdotospermus* Garcke Dinter 7513
- 270 *H. sabdariiffa* L. Kinges 3422
- 271 *H. schinzii* Guerke Leistner 1692
- 272 *H. sidiformis* Baill. Galpin 12237
- 273 *H. subreniformis* Burtt Davy Strey 3072
- 274 *H. sulfuranthus* Ulbr. Strey 2551
- 275 *H. surattensis* L. Dohse 275
- 276 *H. tiliaceus* L. Edwards 2607
- 277 *H. trionum* L. Taylor 2585
- 278 *H. upingtoniae* Guerke Schoenfelder 559
- 279 *H. upingtoniae* Guerke De Winter 2943
- 280 *H. vitifolius* L. subsp. *vitifolius* Flanagan 1071
- 281 *H. vitifolius* L. subsp. *vitifolius* Pegler 1266
- 282 *H. vitifolius* L. subsp. *vulgaris* Brenan & Exell Meeuse 9731
- 283 *H. waterbergensis* Exell Theron 2137
- 284 *Kosteletzkya buettneri* Guerke Killick & Leistner 3420

Tribe: Malveae

- 285 *Lavatera cretica* L. Acocks 20742
- 286 *Malva neglecta* Wallr. Louw 559
- 287 *M. parviflora* L. Acocks 21816
- 288 *M. parviflora* L. Schmitz 236
- 289 *M. pusilla* Sm. Theron 158
- 290 *M. sylvestris* L. Mostert 995

Tribe: Abutilaeae

Subtribe: Abutilinae

- 291 *Abutilon angulatum* (Guill. et Perr.) Mast. var. *angulatum* Oates 22
- 292 *A. angulatum* (Guill. et Perr.) Mast. var. *microphyllum* (Bak.f.) Hochr. Boss 440
- 293 *A. austro-africanum* Hochr. Leistner 913
- 294 *A. dinteri* Ulbr. Volk 2438
- 295 *A. englerianum* Ulbr. Dinter 7358
- 296 *A. fruticosum* Guill. & Perr. De Winter & Leistner 5432
- 297 *A. galpinii* A.Meeuse Tinley 512

- 298 *Abutilon galpinii* A.Meeuse Ward 2185
- 299 *A. grandifolium* (Willd.) Sweet Bowker (Sept. 1922) s.n.
- 300 *A. grantii* A.Meeuse Strey 6454
- 301 *A. hirtum* (Lam.) Sweet West 5511
- 302 *A. matopense* Gibbs Meeuse 9792
- 303 *A. mauritianum* (Jacq.) Don. Ward 6301
- 304 *A. mendoncae* Bak.f. De Winter & Leistner 5467
- 305 *A. piloso-cinereum* A.Meeuse Henrici 2008
- 306 *A. pycnodon* Hochr. Leistner 2337
- 307 *A. ramosum* Guill. & Perr. Van der Schijff 2721
- 308 *A. rehmannii* Bak.f. De Winter 2883
- 309 *A. sonneratianum* (Cav.) Sweet Meeuse 9429
- 310 *Anisodonteia anomala* (Link & Otto) Bates Hardy 804
- 311 *A. biflora* (Desr.) Bates Esterhuysen 15991
- 312 *A. bryoniifolia* (L.) Bates Leistner 344
- 313 *A. capensis* (L.) Bates Marsh 939
- 314 *A. capensis* (L.) Bates Galpin (9.9.1897) s.n.
- 315 *A. elegans* (Cav.) Bates Theron 2079
- 316 *A. julii* (Burch. ex DC.) Bates subsp. *julii* Ruch 1614
- 317 *A. julii* (Burch. ex DC.) Bates subsp. *pannosa* (H.Bol.) Bates Killick 3854
- 318 *A. julii* (Burch. ex DC.) Bates subsp. *prostrata* (E. Mey. ex. Turcz.)
Bates Flanagan 1506
- 319 *A. malvastroides* (Bak.f.) Bates Theron 618
- 320 *A. procumbens* (Harv.) Bates Bayliss 1173
- 321 *A. racemosa* (Harv.) Bates Thode A2101
- 322 *A. scabrosa* (L.) Bates Taylor 3988
- 323 *A. setosa* (Harv.) Bates Bolus 8413
- 324 *A. triloba* (Thunb.) Bates Olivier 16
- 325 *Malveopsis grossulariaefolia* (Cav.) Kuntze Acocks 23641
- 326 *M. scabrosa* (L.) Stapf Marsh 582
- 327 *Sphaeralcea bonariensis* (Cav.) Griseb. Brueckner 17
- 328 *Wissadula rostrata* (Schumach.) Hook.f. Codd 5343

Subtribe: Sidinae

- 329 *Malvastrum coromandelianum* (L.) Garcke Gerstner 3864
- 330 *M. scabrosum* (L.) Stapf Bos 120
- 331 *M. virgatum* Gray & Harv. Gemmell 5054
- 332 *Sida acuta* Burm.f. Van der Schijff 496
- 333 *S. alba* L. Trauseld 982
- 334 *S. chrysantha* Ulbr. Repton 4776
- 335 *S. chrysantha* Ulbr. Ihlenfeldt 2286
- 336 *S. cordifolia* L. Strey 6565
- 337 *S. hoefnieri* Guerke. De Winter 2904
- 338 *S. hoefnieri* Guerke. Bradfield 164A
- 339 *S. hoefnieri* Guerke. Brueckner 1316
- 340 *S. pseudocordifolia* Hochr. Strey 9785
- 341 *S. rhombifolia* L. Wells 3377
- 342 *S. spinosa* L. Hanekom 1689
- 343 *S. ternata* L.f. Louw 1025

Tribe: Ureneae

- 344 *Pavonia burchellii* (DC.) R. A. Dyer Van Vuuren 515
- 345 *P. clathrata* Mast. De Winter 4320
- 346 *P. columella* Cav. Strey 4158

- 347 *Pavonia dentata* Burtt Davy Meeuse 31266
348 *P. dregei* Garcke Scott-Smith 69
349 *P. elegans* Garcke Codd 5703
350 *P. leptocalyx* (Sond.) Ulbr. Meeuse 9184
351 *P. praemorsa* Willd. Sidey 3427
352 *P. senegalensis* (Cav.) Leistner Giess 9956
353 *Radyera urens* (L.f.) Bull. Banks 103

2.3 Acetolysis

To introduce a common basis for the comparison of pollen from herbarium sheets of varying age, as well as to remove adhering debris, all specimens were acetolysed before examination. In their study of the pollen of the Compositae, Skvarla & Turner (1966) also stress the use of acetolysed pollen for the same reasons.

The acetolysis procedure also causes dehydrated, collapsed pollen grains to resume their normal shape (Ridgway & Skvarla, 1969). Examination of the pollen grains is thus simplified.

The traditional method of acetolysis, as supplied by Erdtman (1960, 1969) was slightly modified for use with small numbers of pollen grains. The complete procedure employed is as follows: Polleniferous parts (usually anthers, but often parts of the floral column, and occasionally complete small flowers), were deposited in rimmed Durham tubes (5 × 30 mm) and covered with the standard acetolysis mixture of 9:1 acetic acid anhydride and concentrated sulphuric acid. The tubes were then heated in a water bath at 95 ° for 5 minutes and thereafter centrifuged at 2 000 × g for 60 minutes. The acetolysis mixture was carefully removed by aspiration with a vacuum needle. Distilled water was added to the pollen in the tubes and the pollen suspended in the water. The tubes were then centrifuged again at 2 000 × g for 10 minutes, after which the water was decanted. The pollen was washed twice more with distilled water (removal of water by decantation after centrifugation) to remove all traces of the acetolysis mixture. This is of great importance if the pollen is subsequently to be examined in the scanning electron microscope. Traces of the reagent cause a visible, unevaporable film to be deposited on the pollen as soon as all the water is removed during vacuum coating. This film obscures the surface detail of the pollen. After the final wash in water, most of the liquid was decanted and the pollen resuspended in the small remaining volume of water in the tube.

As the accepted methods of storage of pollen samples, described by Erdtman (1966), caused contamination of the pollen with adhering glycerin jelly when additional aliquots were needed for electron microscopy, water with a trace of phenol as preservative, was used instead.

It is a well-known fact that pollen grains may swell or distort unpredictably after different preparation techniques have been used (Andersen, 1961;

Erdtman & Praglowski, 1959; Van der Spoel-Walvius & de Vries, 1964) and that different embedding materials may cause the same aberrations. Praglowski (in Erdtman & Praglowski, 1959) points out that swelling of thin-walled pollen, embedded in glycerin jelly, measured over three years, amounts to 3,3 % to 4,3 % if the pollen was not chlorinated after acetolysis. This is not in agreement with the 16 % increase found by Andersen (1961) in the same thin-walled pollen. Thick-walled pollen, however, swells only by 0,7 % to 2,9 % under the same circumstances (Praglowski, 1970).

In the course of this study some pollen grains were measured repeatedly during an interval of approximately three years and only small differences (0,5 % to 1,8 %) were found between the first and last measurements. These aberrations were apparent in the diametrical dimensions of the pollen grains, while no differences were encountered in other structures measured.

The only real alternative to glycerin jelly as a mounting medium, is silicone oil, which has a different index of refraction. This difference allows slightly finer detail to be resolved on the pollen grain (Berglund, Erdtman & Praglowski, 1959). During this survey fine detail was studied by means of the electron microscope, thus the indices of refraction of the embedding media were considered to be of negligible importance. Owing to certain practical advantages, the use of glycerin jelly was therefore preferred.

2.4 *Optical microscopy*

To prepare material for use in the optical microscope, a very small piece (less than 0,5 mm³) of glycerin jelly was dipped in the pollen suspension in a Durham tube or storage vial and mounted on a microscope slide. After covering the pollen with a coverslip, the jelly was heated to its melting point and the coverslip was ringed with melted paraffin wax to seal the mounted specimens.

Measurements were made with a Zeiss photomicroscope with apochromatic oil-immersion optics and an eyepiece micrometer.

2.5 *Electron microscopy*

To prepare the material for scanning electron microscopy, a small volume of the pollen suspension was deposited on a chemically cleaned electron microscope object carrier and allowed to dry in the air.

Most of the pollen samples were vacuum coated with 40/60 gold/palladium alloy. A few samples were coated with silver, which gave less satisfactory results.

Some pollen grains exhibited exine characteristics which necessitated relatively high-resolution views of the exine as seen in cross section. The resolution required was too high to be attained in optical sections of pollen grains with the light microscope. Instead of preparing thin sections for

transmission electron microscopy, object carriers with adhering pollen were pressed against glass microscope slides to crush and shatter some of the pollen grains. The broken edges of these grains could then easily be studied with the scanning microscope.

2.6 *Acquisition of data*

A certain number of characteristics cannot, or can only with great difficulty be expressed in quantitative form. These characteristics are therefore given in qualitative terms even though this may not be completely desirable for numerical analysis.

2.6.1 *Quantitative measurements*

Optical microscopy

The optical microscope was used to determine the dimensions given below.

- a. Polar diameter. This measurement was taken between the outer part of the sexine (sensu Erdtman, 1952) of one pole and the corresponding point on the other pole. In species where the outer surface of the sexine is sinuous due to the presence of spines, the polar diameter was taken between points where the exine appears to be at its thinnest.
- b. Equatorial diameter. This dimension was measured in the same way as the polar diameter and in spherical grains was taken as exactly the same as the polar diameter.
- c. Length of colpi.
- d. Thickness of the exine in the mesocolpial area, measured as near to the equator as possible. In spiny grains this measurement was taken in the area between adjacent spines where the exine is at its thinnest. Measurements of the exine thickness in the different areas of the pollen grain were taken from optical sections.
- e. Thickness of the exine at a pore. This measurement represents the apparent thickness of the exine as seen with the optical microscope and does not always correspond well with the same thickness as measured on broken pollen grains observed with the electron microscope.
- f. Thickness of the exine in the polar area.
- g. The ratio of sexine thickness to nexine thickness (nexine used sensu Erdtman 1952). These dimensions were both measured in the polar region of colpate grains and in the area between adjacent spines in other grains. These values were assigned to one of the following states, each representing a different spread of values for sexine thickness \div nexine thickness.

- 0 : >2
- 1 : 1,6 – 1,99
- 2 : 1,2–1,59
- 3 : 0,8–1,19
- 4 : 0,5–0,79
- 5 : 0,3–0,49
- 6 : <0,29

Scanning electron microscopy

Scanning electron micrographs were printed at known magnifications. The dimensions of structures were measured directly on the prints by means of a vernier gauge and the sizes calculated and expressed in μm .

The following structures were measured.

- a. The length of spines or spinules.
- b. The basal diameter of spines or spinules.
- c. The length of lacunae (the area between the meshes of the reticulum, sensu Erdtman, 1943).
- d. The width of the lacunae. When the width and the length of the lacunae were approximately equal, the same size was used for c and d.
- e. The diameter of the areolar area at the base of most spines (Fig. 1). In cases where no visible areolus was present, the size used was the same as that of the basal diameter of the spines present.
- f. The width of the muri surrounding the lacunae.
- g. The number of spines.

2.6.2 *Qualitative data*

Optical microscopy.

The following data were obtained from studies with the optical microscope.

- a. L.O. pattern (the different patterns observed on the pollen surface, obtained by successive focal adjustments of the microscope, Erdtman, 1956). This feature was assigned to one of the following classes, depending on the appearance. O : No L.O. pattern visible. In this class are included the spinose pollen grains where a true L.O. pattern was not visible. A rather coarse pattern, changing in brightness with varying focus, as is the case in normal L.O. patterns, was observed (Fig. 5). This, however, was due to the presence of pits or perforations in the sexine, and is here treated as being distinct from the normal L.O. patterns where baculi contribute to the pattern.

- 1 : A pilate pattern.
2 : A retipilate pattern.
3 : A reticulate pattern with the muri simplibaculate (Fig. 6).

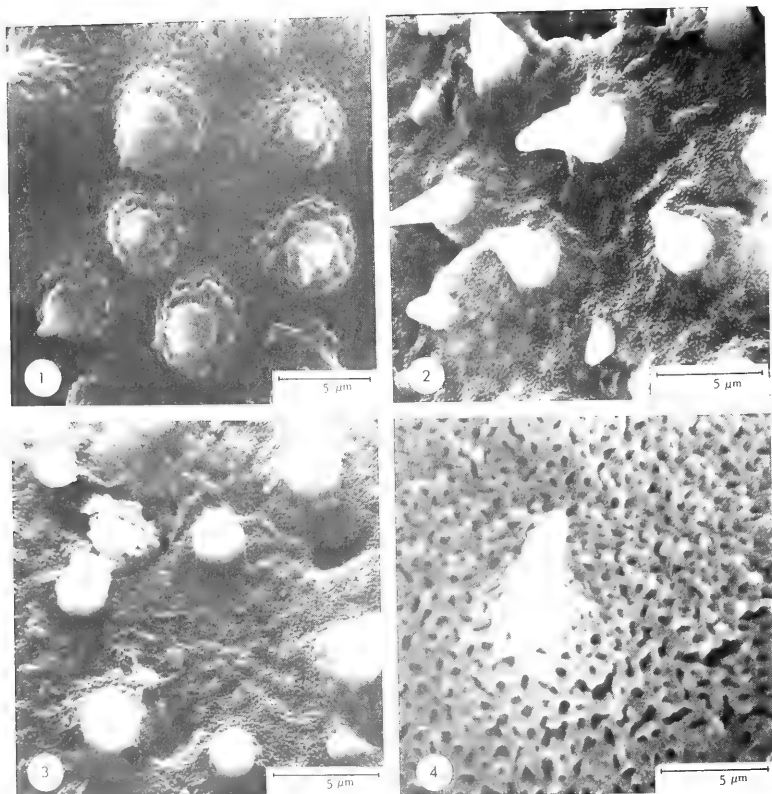


FIG. 1.

Pollen surface of *Abutilon fruticosum* illustrating the areolar area at the base of the spines.

FIG. 2.

Pollen surface of *Malva parviflora* illustrating spinal dimorphism.

FIG. 3.

Sexine surface detail of the pollen of *Malva neglecta*.

FIG. 4.

Sexine surface detail of the pollen of *Melhanhia forbesii*.

4 : A reticulate pattern with the muri duplibaculate (Fig. 7).

5 : A scrobiculate pattern.

6 : An areolate pattern (Fig. 8).

(The descriptions used for classes 1–6 are according to Erdtman, 1966).

b. Spine shape.

The shape of the tip of the spine was assigned to one of three classes.

0 : No spines present.

1 : Spines blunt.

2 : Spines sharp.

c. Pollen grain colour.

The colour of pollen grains after acetolysis may vary, but pollen grains of a species still tend to be either lighter or darker in colour. The colour observed most often in pollen grains of a given species was thus assigned to one of the following states.

0 : Nearly invisible in transmitted light, due to absence of colour.

1 : Very light in colour.

2 : Light in colour.

3 : Intermediate in colour.

4 : Dark in colour.

5 : Very dark in colour (almost no light transmitted through the grains).

d. The number, position and characteristics of the pores (N.P.C.). These attributes of the pollen grains were assigned to one of the N.P.C. classes as in Erdtman (1969) and Erdtman & Straka (1961). According to this index N may be represented by classes 0 to 8, P may be represented by classes 0 to 6 and C may be represented by classes 0 to 6.

Scanning electron microscopy

The following data were obtained from the electron micrographs.

a. Dimorphism of spines. This was expressed by assigning the prominence of dimorphism to one of three states.

0 : Was used to indicate that spines were absent or that no dimorphism was observed.

1 : Was used to indicate that weakly developed dimorphism was present.

2 : Denotes that two or more spine types were very prominently displayed (Fig. 2). The presence of microspinulae and spinelike granules were not taken into account in the placement in one of these states.

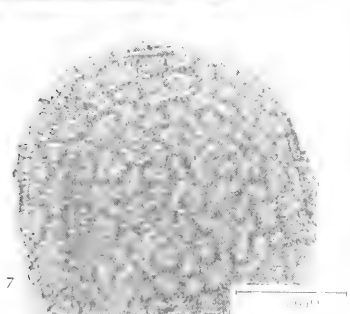
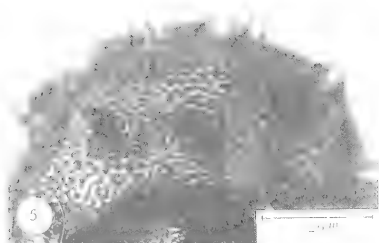


FIG. 5.

The "L.O." pattern on the pollen grain surface of *Melhania acuminata*.

FIG. 6.

The L.O. pattern on the pollen surface of *Hermannia trifoliata*.

FIG. 7.

The L.O. pattern on the pollen surface of *Grewia avellana*.

FIG. 8.

The L.O. pattern on the pollen surface of *Grewia vernicosa*.

- b. The texture of the sexine surface. This variable was expressed by assignment to one of the following states.
- 1 : The sexine surface smooth, without pits, warts or granules and with no reticulation.
 - 2 : The sexine surface rough, without pits or openings other than the pores, with warts or granules, but without any reticulation (Fig. 3).
 - 3 : The sexine surface as in 1 or 2, but with pits or small openings, without reticulation (Fig. 4).

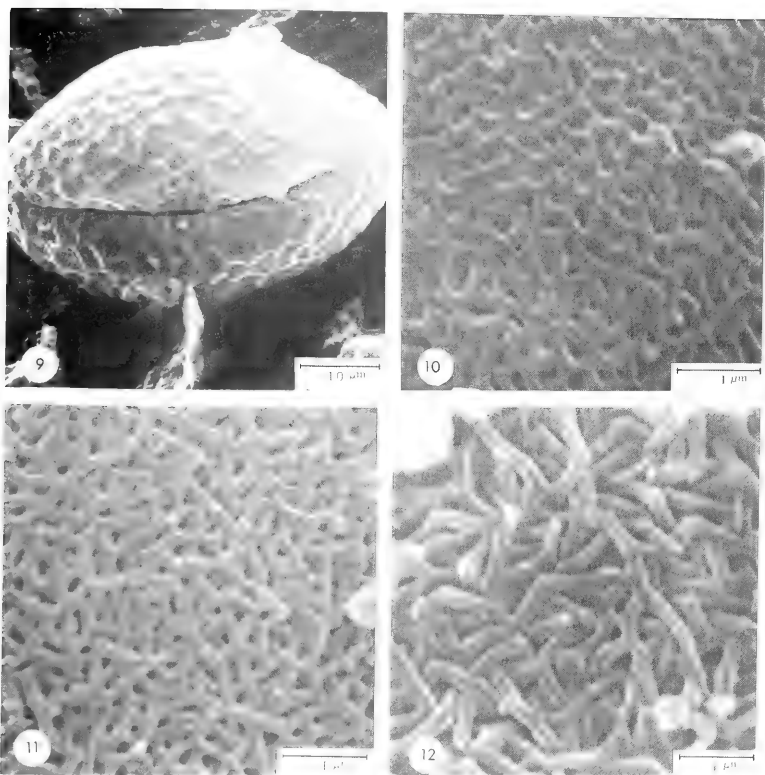


FIG. 9.

Bold reticulation pattern of the sexine of *Grewia occidentalis*.

FIG. 10.

Reticulation pattern and superimposed striations on the sexine of *Hermannia elliottiana*.

FIG. 11.

Reticulation pattern and superimposed striations on the sexine surface of the pollen of *Hermannia desertorum*.

FIG. 12.

Striation pattern on the sexine surface of the pollen of *Hermannia rudis*.

4 : The sexine surface with a barely visible reticulation pattern.

5 : The sexine surface with a bold reticulation pattern (Fig. 9).

6 : The sexine surface with a reticulation pattern and a barely visible superimposed striation pattern (Fig. 10).

7 : The sexine surface with a reticulation pattern (which may vary from clearly to hardly visible) and a superimposed striation pattern (Fig. 11).

8 : Exine surface with a striation pattern only (Fig. 12).

2.6.3 *Computed values*

The maximum and the minimum dimensions of a given quantitative attribute, as observed over all samples of any one species, were also considered to be a characteristic of that species.

The percentage variation of any quantitative characteristic within a species was computed as

$$\frac{\text{max. dimension} - \text{min. dimension}}{\text{min. dimension}} \times 100$$

and could be utilised in the analysis.

The following data groups can be used in the computation of indices of similarity:

1. All data including percentage variation of characteristics used in computation. This method takes into account the measure of specialisation of a taxon, as well as the normal affinities. Taxa with less variation of characteristics are thus grouped together and taxa with a large variation are also grouped together. This data-group was used for interpretative purposes only.
2. All data except percentage variation used in calculations.
3. It must be emphasised that indirect weighting of certain characteristics result from the use of this data as such characteristics are given as separate average, minimum and maximum property-strings. A third data-group was therefore introduced, in which all data except percentage variation, minimum and maximum values and calculated ratios was used.

By comparing dendrograms constructed from data as in (1), (2) and (3), tentative deductions can be made as to the delimitation of taxa.

2.7 *Synoptic list of characteristics useful in pollen analysis*

1. Average polar diameter.
2. Minimum polar diameter.
3. Maximum polar diameter.
4. Percentage variation of polar diameter.
5. Average equatorial diameter.
6. Minimum equatorial diameter.
7. Maximum equatorial diameter.
8. Percentage variation of equatorial diameter.

9. Average spine length.
10. Minimum spine length.
11. Maximum spine length.
12. Percentage variation of spine length.
13. Average number of spines.
14. Average spine diameter.
15. Minimum spine diameter.
16. Maximum spine diameter.
17. Percentage variation of spine diameter.
18. Average length of colpi.
19. Minimum length of colpi.
20. Maximum length of colpi.
21. Percentage variation in length of colpi.
22. Average exine thickness in the mesocolpium.
23. Minimum exine thickness in the mesocolpium.
24. Maximum exine thickness in the mesocolpium.
25. Percentage variation in exine thickness in the mesocolpium.
26. Average exine thickness at a pore.
27. Minimum exine thickness at a pore.
28. Maximum exine thickness at a pore.
29. Percentage variation of exine thickness at a pore.
30. Average exine thickness at the pole.
31. Minimum exine thickness at the pole.
32. Maximum exine thickness at the pole.
33. Percentage variation of exine thickness at the pole.
34. Average lacunar length.
35. Minimum lacunar length.
36. Maximum lacunar length.
37. Percentage variation in lacunar length.
38. Average lacunar width.
39. Minimum lacunar width.
40. Maximum lacunar width.
41. Percentage variation of lacunar width.
42. Average areolar diameter.
43. Minimum areolar diameter.
44. Maximum areolar diameter.
45. Percentage variation of areolar diameter.
46. Average width of muri.
47. Minimum width of muri.
48. Maximum width of muri.
49. Percentage variation of width of muri.

- | | | |
|-----|--------------------------------|------|
| 50. | Areolar diameter | (42) |
| | spine diameter | (14) |
| 51. | Exine thickness at the pole | (30) |
| | exine thickness in mesocolpium | (22) |
| | Spine length | (9) |
| 52. | spine diameter | (14) |
| | Polar diameter | (1) |
| 53. | colpium length | (18) |
| | Muri width | (46) |
| 54. | lacuna width | (38) |
| | Lacuna length | (34) |
| 55. | lacuna width | (38) |
| 56. | Shape of spine. | |
| 57. | Texture of exine. | |
| 58. | L.O. pattern. | |
| 59. | Sexine thickness | |
| | nexine thickness | |
| 60. | Colour. | |
| 61. | Spine dimorphism. | |
| 62. | Number of apertures (N). | |
| 63. | Position of apertures (P). | |
| 64. | Character of apertures (C). | |

2.8 *Determination of phenetic relationships*

A great variety of different procedures (Sneath & Sokal, 1973, Clifford & Stephenson, 1975) may be employed to determine phenetic relationships (Cain & Harrison, 1960) of different members of a group. A variety of computational methods were used and the results will be presented elsewhere.

3. RESULTS

3.1 *Construction of the key*

The choice between an analytical key and a synoptical key is not straightforward. Both keys have their own inherent advantages and disadvantages. Leenhouts (1966) gave prominence to the impressive advantages of the synoptical key. These advantages are, amongst others, the full use of striking or exclusive characters, the easy delimitation of taxa on account of a combination of characters, the easy mutual comparison of taxa and finally, the high reliability of this method. The disadvantages of the synoptical system are enumerated by Korf (1972). The most important of these is the fact that such a key is cumbersome to use when it incorporates a large

number of taxa. This drawback may be minimised when the characteristics are divided into smaller subgroups. If these subgroups are made small enough, the number of species in any one subgroup should not be unmanageable.

The choice of the size of subgroups is not easy, because each size of group chosen must be laboriously sorted by hand. This trial and error method can be extremely time consuming and is always subject to errors.

For this reason a computer program was written which allowed subgroup sizes to be adjusted until the optimum size was reached.

The optimum size depends on the number of taxa incorporated, as well as the ranges of values in each species encountered for any one characteristic. If the spread of values for a characteristic is very large, no purpose is served by choosing very small range subgroups, as these subgroups would contain nearly as many species as larger subgroups. It would, in this case, be disadvantageous to use very small subgroups, as the large number of subgroups more than cancel out the advantage of slightly smaller numbers of species in each group.

The benefits of the synoptical system of identification were, for the purposes of pollen identification, considered greater than the disadvantages, and this system is used here.

One of the primary considerations was the fact that this key may be used with data from optical microscopy only, even though data which may only be obtained with the aid of the scanning electron microscope is also included.

This would not, in most cases, lead the user to the single correct species, but would at least allow him to eliminate a large number of other possibilities. An analytical key to a group such as this would necessitate the use of characteristics obtained from optical and electron microscopy.

Any one species usually appears in more than one subgroup of the quantitative characteristics, because the range of values of the species for that characteristic is usually larger than the value range of the subgroup.

The numbers following each division of a characteristic in the key are the same numbers assigned to the taxa in the list of investigated material.

3.2 KEY

(numbers correspond with those used in the list of investigated taxa)

1. POLAR DIAMETER OF COLPATE POLLEN AND DIAMETER OF PORATE POLLEN

Less than 15.0 μ m

76 82 84 87 88 91 93 96 100 108 110 115 116 117 118 123 125 126 127 128 129 131
132 133 134 136 138 144 147 148 150 151 153 154 157 159 161 162 168 172 175 177 179 180
182 184 187 194 195 197 200 204 205 206 208 210 212 213

15.1 to 20.0 μ m

75 76 80 82 84 85 87 89 91 92 96 100 103 108 115 116 117 118 124 125 127 133
134 135 138 144 147 148 151 152 160 163 168 171 177 179 182 187 194 195 196 197 198 200
204 205 208 210 211 219

20,1 to 22,5 μm

36 75 77 81 90 93 97 106 111 121 137 139 155 156 160 167 170 171 173 174 178 191
192 213 214 215 219

22,6 to 25,0 μm

79 80 86 99 105 106 107 113 114 119 120 124 135 137 139 140 142 143 145 149 164 165
166 167 170 174 183 186 192 196 203 209 211

25,1 to 27,5 μm

3 7 29 77 81 83 90 94 99 104 109 111 112 120 130 141 152 158 165 169 173 176
178 181 183 185 186 189 190 199 215

27,6 to 30,0 μm

29 43 44 45 48 53 79 97 98 102 107 114 145 149 155 156 188 191 202 207

30,1 to 35,0 μm

3 6 7 10 11 12 35 36 39 42 44 50 54 56 58 78 86 94 101 104 105 109
112 113 130 140 141 142 143 146 158 164 169 176 181 185 193 199 202 214 216 217 218 220

35,1 to 40,0 μm

1 4 5 8 9 10 12 15 21 23 35 47 49 50 52 53 54 55 56 58 59 95
98 102 119 121 122 146 166 190 193 201 203 207 209 216 217 327 343

40,1 to 50,0 μm

2 6 8 9 11 13 14 15 17 19 21 25 30 32 40 42 43 45 46 47 49 51
52 55 57 59 60 62 64 68 78 83 95 101 122 188 189 201 218 286 320 324 327 340

50,1 to 60,0 μm

2 5 16 18 20 22 24 26 27 28 31 34 37 38 40 41 48 51 62 65 68 70
71 72 73 74 221 286 289 298 307 310 311 313 315 325 326 331 334 337 338 339 343

60,1 to 70,0 μm

4 18 19 23 25 26 27 28 30 32 33 34 38 41 57 61 63 64 67 70 71 73
74 231 289 293 294 295 296 298 299 300 302 303 305 307 308 309 310 311 312 313 314 315
318 321 323 330 331 334 335 338 339 341 342

70,1 to 80,0 μm

22 31 37 60 61 63 67 69 224 230 231 237 258 260 287 293 294 295 296 299 300 301
303 308 312 314 318 319 321 323 325 328 332 336 337 340 342

80,1 to 90,0 μm

66 69 223 224 227 229 230 233 237 241 242 246 250 258 259 268 272 274 281 287 290 292
297 301 304 305 309 316 319 329 333 335 341 353

90,1 to 100,0 μm

223 225 226 227 229 233 235 236 238 242 243 246 248 254 260 264 267 272 273 274 278 283
291 306 317 322 329 330 336 348

100,1 to 110,0 μm

234 235 236 239 240 245 248 250 251 255 259 261 263 265 267 268 269 277 278 281 282 283
284 285 297 302 306 316 322 344 347 348 349 350 351 353

110,1 to 120,0 μm

225 226 234 241 245 249 251 253 254 256 262 264 265 266 269 270 271 275 276 277 280 284
285 291 333 349

120,1 to 140,0 μm

222 228 232 238 239 240 243 247 249 252 256 257 261 262 263 266 270 271 273 275 276 279
288 290 345 346 350 351 352

More than 140,1 μm

244 247 253 255 257 279 280 282 288 344 345 346 352

2 EQUATORIAL DIAMETER OF COLPATE POLLEN AND DIAMETER OF PORATE POLLEN

Less than 10,0 μm

82 88 110 128 129 134 136 147 150 157 172 195 208 212

10,1 to 15,0 μm

75 76 80 82 84 85 87 88 89 91 92 93 96 100 103 108 110 115 116 117 118 123
 124 125 126 127 128 129 131 132 133 134 135 136 138 144 147 148 150 151 153 154 157 159
 160 161 162 163 168 171 172 175 177 179 180 182 184 187 194 195 196 197 198 200 204 205
 206 208 210 212 213

15,1 to 20,0 μm

4 6 7 11 29 36 42 43 44 47 48 49 80 81 90 92 93 103 105 106 111 124
 135 137 139 144 145 152 155 156 160 167 170 171 173 174 178 179 183 187 191 194 196 198
 200 205 211 213 215 219

20,1 to 25,0 μm

1 3 5 8 10 11 12 13 14 15 21 29 43 44 45 50 51 75 77 79 81 83
 86 90 97 99 104 106 107 109 111 113 114 119 120 121 137 139 140 141 142 143 149 152
 155 164 165 166 167 169 174 176 178 181 183 186 190 192 199 203 207 209 214 219

25,1 to 30,0 μm

2 3 8 9 14 15 17 23 33 35 42 46 47 49 50 52 53 77 78 79 94 95
 97 98 102 104 105 107 109 112 113 114 120 130 140 142 143 145 146 149 156 158 169 173
 176 181 185 188 189 191 193 199 202 214 215 216

30,1 to 35,0 μm

9 19 21 24 25 27 38 39 40 41 45 51 52 54 56 58 83 86 94 98 101 122
 130 141 158 164 185 190 193 202 209 216 217 218 220

35,1 to 40,0 μm

2 4 5 6 13 16 17 20 26 30 33 34 35 37 48 53 54 55 56 58 59 78
 95 101 102 119 121 146 166 188 189 201 203 207 217 327 343

40,1 to 50,0 μm

16 18 19 20 22 27 31 32 38 40 55 57 59 60 62 64 68 70 122 201 286 320
 324 327 340

50,1 to 60,0 μm

18 22 23 25 26 28 30 31 32 34 37 41 62 65 68 70 71 72 73 74 221 286
 289 298 307 310 311 313 315 325 326 331 334 337 338 339 343

60,1 to 70,0 μm

57 61 63 64 66 67 71 73 74 221 231 289 293 294 295 296 298 299 300 302 303 305
 307 308 309 310 311 312 313 314 315 318 321 323 330 331 334 335 338 339 341 342

70,1 to 80,0 μm

60 61 63 66 67 69 224 230 231 237 258 260 287 292 293 294 295 296 299 300 301 303
 308 312 314 318 319 321 323 325 328 332 336 337 340 342

More than 80,1 μm

69 222 223 224 225 226 227 228 229 230 232 233 234 235 236 237 238 239 240 241 242 243
 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265
 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 287 288
 290 291 292 297 301 302 304 305 306 309 316 317 319 322 329 330 333 335 336 341 344 345
 346 347 348 349 350 351 352 353

3. LENGTH OF SPINES

Less than 3,0 μm

53 54 55 58 59 60 68 221 286 287 289 296 297 298 310 312 318 319 322 323 324 327
 331 337 338 339 340 343

3,1 to 5,0 μm

56 57 58 60 62 63 70 71 72 223 231 254 275 281 288 290 293 294 296 297 299 300
 301 304 305 306 307 308 309 310 311 312 313 314 315 316 317 319 320 321 323 325 326 328
 329 330 331 332 333 334 335 336 338 339 341 342 343

5,1 to 8,0 μm

57 62 64 65 66 67 68 69 70 71 73 74 223 224 225 226 227 228 229 230 231 237
 250 251 252 265 274 285 288 289 291 292 293 294 295 298 299 301 302 303 304 305 306 308
 309 311 314 315 318 320 322 324 325 330 332 333 334 336 337 340 341 353

8,1 to 11,0 μm

61 64 65 66 69 73 224 227 230 233 235 238 246 250 251 252 253 254 259 260 265 268
270 271 273 280 281 285 286 287 290 317 344 348 350

11,1 to 14,0 μm

67 222 225 228 232 235 236 238 239 240 241 243 246 249 255 258 261 262 269 272 276 277
278 282 291 346 349

14,1 to 18,0 μm

222 233 237 239 241 242 243 244 245 247 248 249 253 255 256 257 259 263 264 266 267 268
270 271 273 275 276 279 280 283 284 344 346 347 350 351

More than 18,1 μm

232 234 236 240 244 245 248 257 261 262 263 264 266 267 272 277 278 279 282 283
284 345 348 349 351 352

4. NUMBER OF SPINES

Absent

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51 52 55 56 57 58 59 60 61 62 63 64 65 66 67 68
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88
89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110
111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132
133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154
155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176
177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198
199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220

Spines present, less than 50

61 62 63 69 71 246 267

51 to 100

53 55 56 57 60 64 65 66 67 68 70 72 73 74 227 232 233 234 235 237 238 239
240 241 242 243 245 247 248 252 253 258 259 260 261 262 263 264 266 269 272 273 274 277
278 279 281 282 283 284 291 347 348 349 350 352

101 to 150

54 58 59 223 230 236 244 249 250 251 254 255 256 257 265 268 270 271 275 276 280 292
295 299 302 306 311 315 318 319 321 344 345 351 353

151 to 250

221 222 224 225 226 229 231 289 293 294 296 297 298 300 301 303 304 305 307 308 309 310
313 316 317 320 322 323 325 326 327 330 331 334 335 337 339 343 346

More than 251

228 285 286 287 288 290 312 314 324 328 329 332 333 336 338 340 341 342

5. BASAL DIAMETER OF SPINES

Less than 2,00 μm

53 54 55 56 58 59 68 72 221 275 286 287 288 289 290 296 297 298 299 300 307 308
309 310 311 312 313 314 315 318 319 320 321 322 324 325 327 328 330 331 332 333 334 335
337 339 340 341 343

2,01 to 2,50 μm

55 56 58 62 63 73 229 231 274 281 285 293 294 297 306 307 310 313 316 321 323 324
326 327 329 336 338 340 342 346

2,51 to 3,00 μm

60 64 67 71 72 223 225 250 254 265 280 295 301 303 305 309 312 317 319 320 323 337
338 339

3,01 to 3,50 μm

60 62 63 65 70 74 226 227 237 243 286 287 292 298 303 304 315 325 326 328 332 333
336 342 343 348 353

3.51 to 4.00 μm

57 61 67 69 71 226 231 238 258 260 288 293 294 295 299 300 304 305 308 316 318 335
341

4.01 to 4.50 μm

65 66 70 74 223 224 225 228 229 230 245 246 250 252 259 263 274 283 285 289 290 291
292 296 301 302 311 322 329 334 344

4.51 to 6.00 μm

57 61 64 68 69 73 222 227 232 233 236 238 241 242 247 248 249 251 252 253 255 256
260 261 262 264 269 271 272 277 282 284 302 306 317 330 331 344 347 350 351 353

6.01 to 7.00 μm

224 232 233 235 237 239 240 242 244 246 247 248 249 255 257 258 259 265 266 267 270 271
273 275 276 278 279 280 281 291 345 349 350 352

7.01 to 9.00 μm

66 222 228 230 234 236 241 243 245 251 253 254 256 261 262 264 266 267 268 269 270 272
273 276 277 279 284 346 347 349

More than 9.01 μm

234 239 240 244 257 263 268 278 282 283 345 348 351 352

6. DIMORPHISM OF SPINES

No dimorphism

53 54 56 57 59 60 61 62 63 65 70 71 72 73 74 222 224 225 227 228 233 234
235 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 255 256 258 259 260
261 262 263 264 265 266 267 268 269 270 271 272 273 276 277 278 279 291 293 296 299 301
302 303 304 305 306 307 309 315 319 320 330 336 341 344 345 347 349 350 351 352 353

Weakly developed dimorphism

55 58 64 66 67 69 221 223 226 229 230 231 237 257 274 282 283 284 285 286 288 290
292 294 295 297 298 300 308 310 311 313 314 316 317 318 321 325 326 327 328 329 331 332
333 334 335 337 338 339 340 342 343 346 348

Prominent dimorphism

68 232 236 254 275 280 281 287 289 312 322 323 324

7. SPINE SHAPE

Spines blunt

55 56 57 59 60 61 63 64 65 66 68 69 70 71 72 74 221 226 227 228 229 232
233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254
255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276
277 278 279 280 282 283 284 285 286 287 288 289 290 292 296 298 300 301 303 305 306 307
309 319 328 329 330 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350
351 352 353

Spines sharp

53 54 58 62 67 73 223 224 225 230 231 281 291 293 294 295 297 299 302 304 308 310
311 312 313 314 315 316 317 318 320 321 322 323 324 325 326 327 331 332 333

8. DIAMETER OF AREOLUS

Less than 3.0 μm

53 54 55 56 58 59 62 68 71 72 73 221 250 254 280 281 285 286 288 289 290 307
312 321 324 327 337 343 346

3.1 to 4.2 μm

56 57 61 62 63 64 67 69 70 71 74 229 237 243 258 259 274 275 283 286 287 288
297 307 310 311 312 313 314 316 318 320 323 326 327 328 329 330 332 338 339 340 343 348

4.3 to 5.0 μm

57 60 61 63 66 70 72 73 224 246 250 252 255 272 285 287 293 296 299 300 301 303
305 308 309 310 314 315 317 319 320 321 322 324 325 331 333 334 335 336 337 338 340 341
342 350 353

5.1 to 6.0 μm

60 64 65 66 67 68 69 74 223 226 231 233 238 245 252 253 256 264 274 275 282 290
294 295 298 304 311 313 315 322 323 326 328 330 331 339 341 342 347 351

6.1 to 7.0 μm

223 224 225 235 238 241 243 255 258 259 260 262 265 276 279 280 281 289 291 296 302 306
309 316 319 325 329 332 335 345 347 349 350

7.1 to 8.0 μm

65 225 232 237 239 240 246 248 249 253 256 260 265 269 273 277 279 294 297 298 300 303
308 317 318 333 336 344 346 352 353

8.1 to 10.0 μm

226 227 228 229 230 231 233 234 236 239 241 242 244 245 247 251 254 261 262 264 266 268
271 272 273 276 277 283 284 292 293 295 299 301 302 304 305 306 344 345 348 349 351

More than 10.1 μm

222 227 230 232 234 236 240 244 247 248 249 257 261 263 266 267 268 269 270 271 278 282
284 291 334 352

9. LENGTH OF COLPI

Less than 9.0 μm

76 88 91 93 103 108 110 115 118 123 125 128 129 131 134 136 138 150 151 153 157 159
161 172 175 180 182 197 200 204 205 206 212

9.1 to 11.0 μm

75 82 83 84 88 89 91 92 96 97 100 106 110 115 116 117 118 123 126 127 128 131
132 134 135 136 141 144 147 148 150 153 154 157 159 161 162 165 168 170 174 177 179 180
184 187 194 195 196 206 208 209 210 212 213 214 219

11.1 to 13.0 μm

76 77 80 82 84 85 87 92 100 102 107 108 113 116 117 121 125 126 127 129 132 133
138 141 144 146 147 148 151 154 163 168 178 179 182 187 188 191 198 199 200 202 204 205
208 209 210 215 219

13.1 to 15.0 μm

3 29 75 79 80 81 83 85 86 87 90 94 96 97 99 101 103 104 106 107 111 112
114 119 120 124 130 135 137 139 140 142 143 145 149 152 155 158 160 163 164 165 167 170
171 173 174 176 177 178 181 183 189 190 194 195 196 197 198 202 203 211 213 214 220

15.1 to 17.0 μm

36 45 77 86 89 90 93 95 98 104 109 113 114 130 137 140 143 145 149 152 155 156
166 167 169 173 183 185 186 191 192 193 207 211 215

17.1 to 20.0 μm

7 43 44 78 79 81 94 101 102 105 109 112 120 121 124 139 142 146 156 158 164 166
169 186 190 192 199 201 217 220

20.1 to 25.0 μm

3 6 7 9 10 11 12 26 29 32 35 36 39 48 50 78 95 98 111 185 188 189
193 201 207 216 217

25.1 to 35.0 μm

1 2 4 5 8 9 10 11 13 14 15 17 21 23 25 28 32 35 39 40 42 43
44 45 46 47 49 52 122 216 218

35.1 to 50.0 μm

2 4 5 6 13 15 16 18 19 20 22 24 27 28 30 31 33 34 37 38 40 41
48 51

More than 50.1 μm

18 19 20 22 23 25 26 27 30 31 33 34 37 38 41 51

10. THICKNESS OF THE EXINE AFTER ACETOLYSIS (MEASURED IN THE MESOCOLPIAL AREA OF COLPATE POLLEN AND BETWEEN ADJACENT SPINES IN SPINOSE POLLEN)

Less than 0.6 μm

79 80 96 103 116 121 128 129 134 135 136 142 146 196 205 208 212

0,7 to 0,8 μm

12 36 44 75 76 82 83 87 88 89 91 92 93 98 104 108 110 115 117 123 124 127
 128 131 132 133 138 147 150 153 154 159 161 162 166 168 170 171 172 177 179 180 189 192
 194 195 197 199 200 201 204 210 212 213

0,9 μm

45 61 75 77 78 80 84 85 86 88 89 90 96 97 98 99 100 102 103 106 107 108
 109 110 112 116 118 119 120 121 122 123 124 125 126 129 130 131 132 133 134 135 136 138
 139 143 144 148 149 150 151 152 153 154 155 156 157 159 161 163 165 166 168 169 170 174
 175 176 178 182 184 187 188 191 193 195 196 198 202 203 204 206 207 208 209 210 221 327

1,0 to 1,1 μm

2 4 12 43 76 77 79 81 83 84 87 90 92 93 94 97 99 100 101 104 106 107
 111 112 113 114 115 117 118 119 120 122 127 137 139 140 141 142 143 144 145 147 152 156
 158 160 164 167 171 173 174 177 179 180 181 182 183 185 186 187 191 192 194 197 198 200
 201 205 209 211 213 304 327

1,2 to 1,3 μm

6 9 14 17 27 29 32 36 48 81 82 86 95 105 109 111 114 140 145 149 165 169
 176 189 190 193 202 293 303 308

1,4 to 1,6 μm

7 11 13 16 25 31 32 33 34 44 45 50 53 54 55 74 78 85 91 95 105 113
 130 155 181 190 199 207 214 215 309

1,7 to 1,8 μm

1 2 3 5 10 14 15 16 18 21 26 27 29 35 40 41 42 43 46 47 50 52
 56 57 58 61 62 94 101 102 141 158 164 185 188 203 220 223 229 296 300 303 305 306
 313 314 318 323 324

1,9 to 2,4 μm

1 3 6 7 8 10 11 13 17 20 22 23 31 35 38 41 42 46 47 49 51 52
 54 55 56 57 58 59 63 67 69 70 71 214 215 216 218 219 220 230 241 243 295 298
 301 302 304 308 313 314

2,5 to 3,0 μm

4 5 9 15 19 20 21 23 30 33 37 38 39 40 48 53 60 64 65 66 67 69
 71 72 73 74 216 217 224 231 233 242 251 253 259 260 264 269 291 293 294 296 298 300
 301 307 309 310 311 312 318 319 328 329 331 333 334 335 338 343

3,1 to 3,5 μm

8 18 22 24 25 26 30 34 37 51 62 63 68 72 218 227 229 241 245 246 247 262
 265 267 268 271 302 306 315 317 319 320 325 330 332 336 340 341 342 353

3,6 to 4,2 μm

24 60 64 65 66 68 70 224 226 227 230 231 233 234 236 238 242 243 249 250 252 255
 258 259 260 264 265 268 273 279 291 297 299 307 311 312 316 317 321 322 323 325 326 329
 330 331 332 334 338 339 340 343 344

4,3 to 5,0 μm

19 28 223 228 232 235 236 237 239 247 248 251 252 253 256 261 262 267 269 271 274 275
 276 283 292 294 295 305 310 316 320 321 322 326 328 333 335 336 337 339 341 353

More than 5,1 μm

28 222 225 226 228 232 234 235 237 238 239 240 244 245 246 248 249 250 254 255 256 257
 258 261 263 266 270 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288
 289 290 292 297 299 315 337 342 344 345 346 347 348 349 350 351 352

11. APERTURAL THICKNESS OF THE EXINE OF COLPATE POLLEN AFTER ACETOLYSIS

Less than 1,6 μm

36 80 84 88 89 108 125 127 128 129 134 136 157 161 172 180 195 196 199 204 205
 208 212

1,7 to 1,8 μm

76 80 82 84 87 100 104 108 110 123 126 127 132 133 138 147 150 151 153 154 157 159
 162 168 175 177 179 182 184 196 197 200 206 208 210 212

1.9 to 2.3 μm

41	50	75	76	87	89	91	96	97	98	100	103	104	110	113	115	116	117	121	123	125	126
129	133	134	135	136	138	148	151	152	153	154	161	162	163	170	177	178	179	180	193	194	195
197	204	205	206	209	210																

2.4 to 2.7 μm

1	6	9	12	22	41	43	46	47	75	79	81	86	90	92	93	97	99	106	107	114	116
118	119	120	122	124	131	137	139	140	143	146	149	152	155	160	165	166	169	170	174	178	182
183	186	188	191	194	198	200	202	211	213	214	220										

2.8 to 3.2 μm

3	25	29	31	32	35	39	42	47	48	50	78	81	85	86	91	92	93	96	98	101	102
111	115	117	118	130	135	137	139	141	142	143	144	145	164	171	176	186	187	189	190	192	193
198	203	213	215	219																	

3.3 to 3.8 μm

1	2	4	5	8	10	11	14	25	29	45	46	77	90	94	99	101	102	103	105	109	111
112	114	121	122	124	130	140	141	144	149	155	156	158	167	169	173	176	183	185	187	192	202
209	219																				

3.9 to 4.5 μm

3	6	7	9	10	11	13	15	16	17	27	30	31	35	37	38	39	42	43	44	51	52
77	79	85	94	105	109	112	113	142	156	158	164	171	173	188	189	190	199	201	207	215	216
217																					

4.6 to 5.5 μm

2	7	13	14	15	18	21	24	27	30	32	33	37	38	45	49	51	52	78	83	95	166
181	185	201	203	207																	

More than 5.6 μm

4	5	8	16	18	19	20	21	22	23	24	26	28	33	34	40	48	49	83	95	181	218
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12. POLAR THICKNESS OF THE EXINE OF COLPATE POLLEN AFTER ACETOLYSIS

Less than 0.7 μm

36	80	83	91	96	103	115	116	121	122	124	128	134	135	136	142	146	166	172	177	195	196
199	201	205																			

0.8 μm

12	75	76	79	88	98	104	123	129	131	153	170	171	172	180	192	194	197	200	212		
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0.9 μm

75	77	80	82	84	86	87	88	89	90	92	93	94	97	100	101	102	106	107	108	110	112
117	118	119	120	125	126	128	132	133	134	136	138	143	144	147	148	149	150	151	152	157	159
161	162	165	168	169	170	174	175	178	179	184	187	189	191	195	196	197	203	204	206	208	209
210	212	213																			

1.0 to 1.1 μm

12	76	78	84	85	87	89	92	93	96	97	98	99	100	103	104	106	107	108	109	110	111
113	114	115	116	117	120	123	124	126	127	129	130	131	132	133	135	137	138	139	140	141	142
143	145	147	152	153	154	155	156	158	160	161	163	164	165	167	168	173	174	176	177	179	180
181	182	183	185	186	188	191	192	193	194	198	200	201	202	204	205	207	208	210	211	213	

1.2 to 1.6 μm

4	6	16	29	34	36	38	43	44	45	47	77	79	81	82	83	85	86	90	91	95	99
101	105	109	111	112	113	114	118	121	122	127	137	140	144	145	149	156	167	169	171	176	181
182	187	189	190	193	199	207	209	214	215												

1.7 to 1.9 μm

1	2	3	5	9	10	11	13	14	15	17	18	23	25	26	27	30	41	42	43	44	48
50	78	94	95	102	130	141	155	158	164	166	185	188	190	202	203	219	220				

2.0 to 2.5 μm

6	7	8	9	15	18	20	21	22	27	29	31	32	33	35	37	40	41	42	46	49	51
52	214	215	216	219	220																

More than 2.6 μm

1	2	3	4	5	8	10	11	13	14	16	17	19	20	21	22	23	24	25	26	28	30
31	32	33	34	35	37	38	39	40	45	46	47	48	51	216	217	218					

13. LENGTH OF LACUNAE

Less than 0,10 μm

75 80 87 91 98 101 102 105 108 109 113 115 133 140 143 144 145 147 151 152 155 167
176 180 181 183 186 194 213

0,11 to 0,13 μm

76 79 81 84 85 90 92 94 97 104 110 117 118 123 124 126 127 130 131 132 137 139
142 149 154 157 160 165 166 168 174 178 179 185 189 190 191 195 196 198 199 200 201 202
209 210 211

0,14 to 0,16 μm

77 83 86 89 100 103 106 111 112 114 116 136 138 148 156 158 159 164 169 171 172 177
182 184 187 188 203 204 206 208 212

0,17 to 0,25 μm

49 78 91 93 95 96 107 119 120 125 128 134 135 137 141 150 151 152 153 161 162 163
170 173 175 186 192 193 197 205

0,26 to 0,35 μm

41 51 75 80 82 85 90 94 102 104 105 110 111 114 118 122 123 129 142 146 150 153
156 166 180 191 199 202 207 208 214

0,36 to 0,45 μm

3 11 42 43 49 79 81 84 86 87 88 92 93 98 99 108 109 113 115 116 127 128
143 154 155 159 161 162 167 173 175 178 179 182 187 194 196 201 205 206 210

0,46 to 0,60 μm

9 44 45 48 50 52 76 82 88 89 95 96 99 106 107 112 119 120 121 124 125 129
130 131 134 135 136 138 139 140 145 147 148 157 158 160 164 165 168 171 172 174 176 177
183 184 189 192 195 203 209 211 212 215 219

0,61 to 1,00 μm

1 2 4 7 10 12 14 17 21 25 26 29 33 35 40 46 77 78 83 97 100 101
103 117 121 122 126 132 133 141 144 146 149 163 169 170 181 185 188 190 193 197 198 200
204 207 213 216

1,01 to 2,00 μm

3 5 6 7 8 9 12 13 14 15 16 17 20 21 22 23 24 27 28 30 31 34
35 36 37 39 40 42 43 44 47 50 51 52 214 215 217 218 219 220

More than 2,01 μm

1 2 4 5 6 8 10 11 13 15 18 19 20 22 23 24 25 26 27 28 29 30
31 32 33 34 36 37 38 39 41 45 46 48 216 220

14. WIDTH OF LACUNAE

Less than 0,07 μm

85 87 90 91 92 93 98 102 105 106 110 118 126 133 144 145 147 152 160 167 172 173
183 192 198 208 211 213

0,08 to 0,10 μm

75 80 81 84 97 100 101 107 108 109 111 112 113 115 117 125 127 137 138 140 150 151
153 155 157 165 168 170 174 176 177 178 180 181 182 184 186 187 190 191 193 194 197 210

0,11 to 0,15 μm

9 49 76 79 85 86 89 94 103 104 105 116 123 124 130 131 132 136 139 142 143 148
149 154 156 158 159 162 163 166 169 173 175 179 185 188 189 191 192 195 196 199 200 201
202 203 206 209 212 215

0,16 to 0,19 μm

75 77 78 82 83 87 88 90 91 92 95 96 98 106 110 111 114 121 135 150 152 156
160 164 171 174 186 190 193 203 204 210

0,20 to 0,24 μm

49 81 84 93 108 112 119 120 128 134 136 137 141 144 147 148 151 153 154 161 167 172
179 183 184 187 198 205 208 211 214

0,25 to 0,30 μm

4 8 51 76 82 89 94 104 107 117 118 125 126 127 132 133 138 145 157 162 165 166
171 175 177 178 180 182 197 199 207 212 213 216

0,31 to 0,40 μm

2 7 13 41 47 80 88 97 99 102 109 113 114 116 122 123 129 142 143 146 159 161
163 168 170 196 202 206 217

0,41 to 0,50 μm

3 10 11 12 15 23 29 37 42 43 46 48 79 86 95 96 100 115 124 128 129 134
135 139 155 158 176 189 194 195 201 205 207 209 215 219

0,51 to 0,70 μm

1 5 6 7 9 14 16 17 21 33 44 45 50 52 77 78 99 101 103 119 120 121
130 131 140 141 164 181 204 214 220

0,71 to 1,50 μm

1 2 3 4 5 6 8 10 12 13 14 15 16 19 20 21 22 23 24 25 26 29
30 35 36 38 40 42 46 47 50 52 83 122 146 149 169 185 188 200 216 217 218 219
220

More than 1,51 μm

11 17 18 19 20 22 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40
41 43 44 45 48 51

15. WIDTH OF MURI

Less than 0,08 μm

49 84 88 93 98 111 118 129 144 147 153 156 171 179 182 187 213

0,09 to 0,11 μm

9 75 76 80 85 87 90 92 103 105 106 108 110 114 116 117 133 134 143 145 148 151
152 160 161 162 167 168 170 172 173 174 177 183 190 192 193 195 196 197 198 204 205 208
211 212

0,12 to 0,14 μm

8 78 81 86 88 89 91 94 95 96 97 100 101 102 109 118 119 122 123 124 125 126
127 128 129 132 135 136 137 138 142 150 153 154 155 157 159 165 169 175 176 180 184 186
191 206 209 211

0,15 to 0,17 μm

2 4 5 10 46 52 77 79 82 83 85 87 92 99 107 111 112 115 120 130 131 136
139 140 150 158 160 162 163 164 167 171 174 176 178 179 181 187 190 192 194 197 198 199
201 202 206 208 210 212 213

0,18 to 0,20 μm

1 7 8 11 17 30 42 47 48 49 51 75 76 80 82 84 93 94 98 99 104 105
110 113 116 117 121 126 135 137 138 139 143 144 145 148 149 152 155 156 159 161 163 166
168 172 175 180 182 185 191 193 200 202 203 204 205 210

0,21 to 0,25 μm

1 2 6 7 10 11 13 14 15 23 33 41 78 81 86 89 90 96 100 103 106 108
109 115 120 122 123 124 125 128 130 131 133 134 140 141 142 146 151 154 157 158 173 177
181 183 184 188 189 194 195 196 201 207 209

0,26 to 0,30 μm

3 4 12 13 14 20 22 24 29 44 45 50 83 95 101 107 114 121 127 132 146 147
149 165 170 178 185 186 199 218 219

0,31 to 0,40 μm

3 5 12 15 16 17 19 20 23 26 35 40 43 45 50 77 79 97 102 104 112 113
119 166 169 188 200 207 214 216 220

0,41 to 0,75 μm

6 9 16 18 19 21 22 24 25 27 28 29 31 32 33 34 35 36 37 38 39 40
41 42 43 44 46 47 48 51 52 91 141 164 189 203 214 215 216 217 218 219 220

More than 0,76 μm

18 25 26 27 28 30 31 32 34 36 37 38 39 215 217

Pollen Morphology of South African Malvales: I

123

16. TEXTURE OF SEXINE SURFACE

Rough, without pits or reticulation pattern, but with warts or granules

222 232 237 240 246 268 270 278 286 287 288 314

Rough, without reticulation pattern, but with pits and warts or granules

53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
221 223 224 225 226 227 228 229 230 231 233 234 235 236 238 239 241 242 243 244 245 247
248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 269 271
272 273 274 275 276 277 279 280 281 282 283 284 285 289 290 291 292 293 294 295 296 297
298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 315 316 317 318 319 320
321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342
343 344 345 346 347 348 349 350 351 352 353

With barely visible reticulation pattern

39

With bold reticulation pattern

1 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41 42 43 44 45 46
47 48 49 50 51 52 76 80 82 83 87 88 91 92 93 97 100 107 108 114 117 118
119 121 127 128 132 133 135 138 143 144 147 148 150 151 153 154 156 159 161 165 170 171
175 179 180 182 187 188 189 194 195 196 198 200 202 203 204 205 212 213 214 215 216 217
218 219 220

With reticulation pattern and barely visible superimposed striations

3 75 77 78 84 86 89 101 102 103 104 110 111 112 113 115 116 120 123 124 125 126
129 130 131 134 136 137 139 140 141 142 145 149 157 158 162 163 164 166 168 169 172 177
178 181 183 184 186 191 193 197 199 201 206 207 208 209 210 211

With reticulation pattern and superimposed striations

79 81 85 90 94 95 96 98 105 109 146 152 155 160 167 173 174 176 192

Striation pattern only

99 106 122 185 190

17. L.O. PATTERN

None visible

9 16 20 23 25 26 34 35 36 38 39 43 51 52 53 54 55 56 57 58 59 60
61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 85 86 88 90 91 92 132
146 190 193 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241
242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263
264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285
286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307
308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329
330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351
352 353

Retipilate

3

Reticulate, muri simplibaculate

1 2 4 5 6 7 8 10 11 12 13 14 15 17 24 29 32 41 42 44 45 46
47 48 49 50 76 77 78 79 80 81 82 83 84 87 89 93 94 95 96 97 98 99
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121
122 123 124 125 126 127 128 129 130 131 133 134 135 136 137 138 139 140 141 142 143 144
145 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167
168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189
191 192 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213
214 215 216 219 221 222

Reticulate, muri duplibaculate

18 19 21 22 27 28 31 33 37 218 220

Areolate

40 217

More than 2.0

[illegible]

1.6 to 1.99

[illegible]

1.2 to 1.59

3 6 10 12 18 39 62 71 114 224 226 274 296 298 300 302 307 313 314 315 316 317
319 322 325 328 331 334

0.8 to 1.19

1	4	55	56	58	59	60	65	68	72	73	221	223	225	227	228	229	230	231	232	234	235
236	237	238	242	245	248	249	251	252	253	254	256	258	259	260	265	268	269	270	271	273	275
276	277	278	279	280	291	293	295	297	299	303	305	306	308	309	310	311	312	318	320	323	324
326	327	329	330	332	333	335	336	337	338	339	340	341	342	343	353						

0.5 to 0.79

53 54 61 64 222 232 233 239 240 241 243 244 247 250 255 263 264 266 267 272 286 290
292 294 344 348

0.3 to 0.49

246 257 261 262 281 282 283 284 285 287 288 289 321 345 346 347 349 350 351 352

Extremely light, nearly invisible in transmitted light

31 34 122 232 249 252

Very light

2	9	13	20	36	40	45	48	66	70	80	82	86	92	93	103	118	124	146	171	193	198
205	208	209	226	247	253	265	267	279	286	288	294	297	307	316	317	319	322	335	336	344	351

Light

[illegible]

Intermediate

[illegible]

Dark

7 10 18 24 28 43 52 53 57 60 64 65 71 73 74 113 217 218 219 220 227 230
234 235 237 239 254 256 257 258 263 268 270 276 277 278 282 283 289 293 299 301 304 310
320 326 332 337 339 340 341 342 345

Very dark, almost opaque

67 236 240 255 264 266 272 280 281 284 290 347 348 349 352 353

344

53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74

345

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
23	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	50	51	52	75	76	78	79	80	81	82	83	84	85	87	88	89	91	92	93
94	96	97	100	101	103	104	105	108	110	111	113	114	115	116	117	118	119	120	121	122	123
124	125	126	127	128	129	130	131	132	133	134	135	136	138	140	141	143	144	146	147	148	149
150	151	152	153	154	156	157	159	160	161	162	163	165	168	169	170	171	172	175	177	178	179
180	182	184	187	188	189	192	193	194	195	196	197	198	200	201	204	205	206	208	209	210	211
212	213	214	216	217	218	219	220														

445

24	77	86	90	95	98	99	102	106	107	109	112	137	139	142	145	155	158	164	166	167	173
174	176	181	183	185	186	190	191	199	202	203	207	215									

764

222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265
266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287
288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309
310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331
332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353

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NOTES ON *TULBAGHIA*: 1. A NEW SPECIES FROM THE EASTERN CAPE AND A LIST OF NEW LOCALITIES

CANIO G. VOSA

(Botany School, Oxford, England)

ABSTRACT

A new species of *Tulbaghia* is described and illustrated with notes on its affinities and its chromosome morphology. A list of new localities for six species of the genus is presented together with a table of chromosome numbers.

UITTREKSEL

NOTAS OOR *TULBAGHIA*: 1. 'N NUWE SOORT VANAF DIE OOS-KAAP EN 'N LYS VAN NUWE VINDPLEKKE

'n Nuwe *Tulbaghia* soort word beskryf met bykomende inligting oor sy verwantskappe en chromosoom-morfologie. 'n Lys van nuwe vindplekke vir ses *Tulbaghia* soorte asook 'n tabel met chromosoomgetalle word aangebied.

In spite of the interesting morphology and charm of its flowers, *Tulbaghia* has until recently been one of the most under-collected genera of South African plants. The genus is also noteworthy cytogenetically especially as it possesses some of the largest chromosomes in the plant kingdom. This was noted by Dyer (1963) and by Vosa (1966a and b). Vosa (1975) has recently revised the cytotaxonomy of the genus describing six new species in the light of the material he collected in the late 'sixties. The present note relates to new material collected by the author during a recent visit to South Africa.

The collection number of the material together with the chromosome count and the type of chromosome complement are indicated in Table 1. Although about 30 collections of *Tulbaghia* were made during the visit, a certain number of plants were not in flower at the time of collection and have not been classified as yet. Their identity and related data will be the subject of further notes in this series. At least one collection has proved to be a new species which had already been recognised as such by the author in the *Tulbaghia* collection in the Herbarium of the Department of Plant Sciences, Rhodes University. The specimen in question had been collected by Mr D. Comins, Director of the Caffrarian Museum, King William's Town and, just twenty years and one day after his original collection, Mr Comins very kindly led me to the place, about 17 km from King William's Town near Tamaha.

TABLE 1
CHROMOSOME COUNTS AND COLLECTION NUMBERS IN *TULBAGHIA*

Name	collection number	2n=	chromosome group
<i>acutiloba</i> Harv.	<i>Vosa</i> 1487 (OX)	12	4
<i>acutiloba</i> Harv.	<i>Vosa</i> 1572 (OX)	12	4
<i>acutiloba</i> Harv.	<i>Vosa</i> 1613 (OX)	12	4
<i>cominsii</i> Vosa	<i>Vosa</i> 1508 (OX)	12	3
<i>cominsii</i> Vosa	<i>Vosa</i> 1781 (OX)	12	3
<i>galpinii</i> Schltr.	<i>Vosa</i> 1780 (OX)	12	5
<i>leucantha</i> Baker	<i>Vosa</i> 1611 (OX)	12	5
<i>ludwigiana</i> Harv.	<i>Vosa</i> 1550 (OX)	12	2
<i>ludwigiana</i> Harv.	<i>Vosa</i> 1552 (OX)	12	2
<i>ludwigiana</i> Harv.	<i>Vosa</i> 1556 (OX)	12	2
<i>montana</i> Vosa	<i>Bayliss</i> 7831 (OX)	12	6
<i>nutans</i> Vosa	<i>Vosa</i> 1536 (OX)	12	2
<i>transvaalensis</i> Vosa	<i>Vosa</i> 1644 (OX)	12	3

Tulbaghia cominsii Vosa, sp. n.

DIAGNOSIS

Planta pusilla affinis *Tulbaghia violaceae* Bak. sed differt statura minore, foliis glaucis, angustioribus (minus quam 1 mm latis), perigonio albedo vel pallide-roseo.

DESCRIPTION (see also Figs 3 and 4)

Planta pusilla (80–)100(–150) mm alta; *foliis* glaucis, *radicalibus* 5–8, erecto-patentibus, angustioribus, linearibus-obtusis, basi dilatatis; *scapo* gracilis, debili, glaberrimo, apice paucifloro; *bracteis* angustissimis, scariosis; *pedicellis* inequalilongis, filiformibus, 10–15 mm longis, coloris plerumque purpureis; *perigonio* albedo vel pallide-roseo; *segmentis* deltoideis, margine inflexis; *tubo* infundibuliforme, roseo vel pallide-purpureo quam *segmentis* longiore; *corona* constans ex 3-ligulis deltoideis, carnosulis, apicis bifidis vel integri-truncatis; *ovario* ovoideo; *stilo* perbrevis, stigmate capitato.

Type: CAPE—3227 (Stutterheim): In kommittee soil on rocky ground, near Tamaha, 17 km from King William's Town, (–BD), 28–9–57, *D. Comins* 1718 (RU 10586).

Chromosome number: 2n=12 (group 3, Vosa, 1975, p. 56); Figs 1 and 2.

A small plant with glaucous, very thin leaves. *Rootstock* a small corm mostly growing singly with one, or rarely two, growing points, 10–15 mm long and ca. 10 mm in diameter. *Roots* few, fleshy, somewhat spindle-shaped, tending to spread sideways. *Leaves* few, glaucous with a purplish base, 100–200 mm long, 0.8 mm wide, very thin. *Scape* (90–)150(–200) mm long. *Umbel* (3–)7(–10)

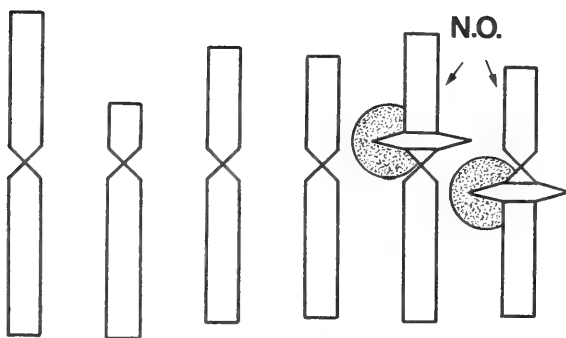


FIG. 1.

Diagrammatic representation of the haploid chromosome complement of *Tulbaghia cominsii* Vosa. Note nucleolar chromosomes (N.O.).

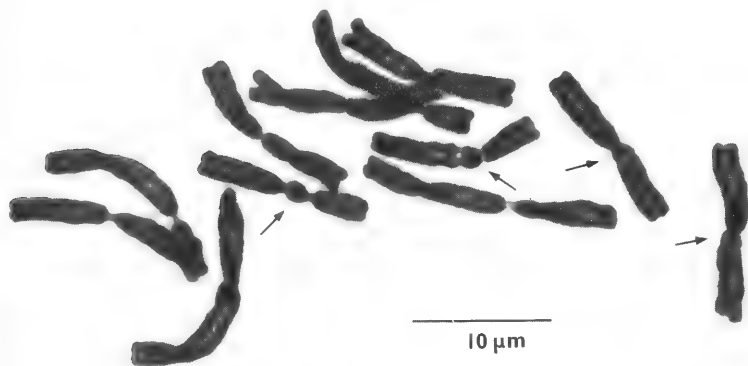


FIG. 2.

Mitotic metaphase chromosomes of *Tulbaghia cominsii* Vosa. Note the four nucleolar chromosomes (arrows).

flowered. *Pedicels* short, often purplish in colour. *Perianth segments* oblong lanceolate with inflexed edges, pure white or pinkish. *Corona* consisting of three separate deltoid, fleshy processes, about half as long as the perianth segments and of the same colour, with an entire or bifid tip. *Anthers* in two whorls. *Ovary* about 1.5 mm long, ovoid. *Style* 1 mm long; stigma capitate.

EXSICCATA AND LIVING MATERIAL

C.G.Vosa 1568, 28-10-77 (OX); *C.G.Vosa* 1781, 12-11-77 (OX), both from the type locality.

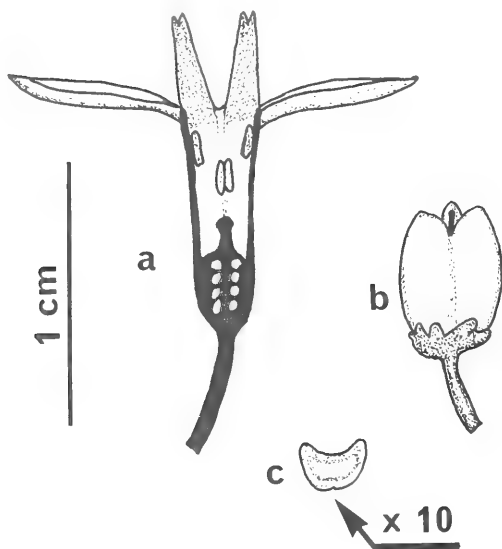


FIG. 3.

Tulbaghia cominsii Vosa: a. flower longitudinal section;
 b. ripe capsule;
 c. cross section of the leaf.

This very beautiful little species is related to *T. violacea* Bak. but differs considerably in having very thin, glaucous leaves, white, or very rarely pinkish flowers with a pink or purplish tube and a different chromosome complement. The glaucous, almost dusty colour of the leaves is very characteristic and is due to the white stomatal pores, which appear as whitish streaks under low magnification. The chromosome morphology is very interesting: it resembles that of *T. transvaalensis* Vosa and *T. macrocarpa* Vosa, two species very different from the present species whose morphological affinities lie with *T. violacea* Bak. This situation, which parallels that of *T. rhodesica* R.E.Fries and *T. cameroni* Baker (see Vosa, 1975, p. 52), is an indication of a two-track evolution in which the karyotype and the phenotype evolve independently and, in this case, along established pathways. There are no chromocentres in the interphase nuclei and Quinacrine staining gives uniform fluorescence along the chromosomes. C-banding produces only very thin bands in positions adjacent to the nucleolar constrictions.



FIG. 4.

Tulbaghia cominsii Vosa: Inflorescence (natural size).

NEW LOCALITIES FOR SPECIES OF *TULBAGHIA*

Tulbaghia acutiloba Harv.

CAPE—3128 (Umtata): 20 km from Butterworth to Umtata, in grazing field at road side (-BD), 6–10–77, *Vosa* 1613 (OX).

—3327 (Peddie): 13 km to Peddie crossroads from King William's Town, in open scrubland, about 200 m. from the left side of the road (-AA), 29–9–77, *Vosa* 1572 (OX).

—3326 (Grahamstown): on koppie, just W. of Salem, in open scrubland (-CB), 21–9–77, *Vosa* 1487 (OX).

Tulbaghia galpinii Schltr.

CAPE—3226 (Fort Beaufort): 11 km from Carlisle Bridge, near the old Cradock road on the left side from Grahamstown, in succulent scrub (-AD.)

Tulbaghia leucantha Baker

LESOTHO—2927 (Maseru): on a rocky outcrop in wet humus, 5 km to road junction from Maseru to Ladybrand (-BB), 26–10–77, *Vosa* 1711 (OX).

Tulbaghia ludwigiana Harv.

CAPE—3326 (Grahamstown): 450 m. from crossroads to Salem from Grahamstown, on road to Vaalvlei, between Denver and Endwell Farms, in grassland (-BC), 28–9–77, *Vosa* 1550 (OX); in a tussocky field just before the

junction to Bathurst on the road to Vaalvlei from Grahamstown, near Glen Hope Farm, in open grassland, 28-9-77, *Vosa* 1552, (OX); at the crossroads to Martindale from Grahamstown, near The Grove and Show Park Farms, in grassland at roadside, 29-9-77, *Vosa* 1572.

Tulbaghia montana Vosa.

CAPE—3028 (Matatiele): 3 km N of Ramatsilitko Gate, Lesotho, in damp rock crevices, 8000 ft. (-DA), 14-11-76, *R.D.Bayliss* 7831 (OX).

Tulbaghia nutans Vosa.

CAPE—3326 (Grahamstown): on left side of the road to Cradock from Grahamstown, near the track to the Vaalkrans, in succulent scrub (-BB), 25-9-77, *Vosa* 1536 (OX). The finding of *T. nutans* Vosa in the Cape considerably extends the range of this species which was previously known only from the Northern Drakensberg (Vosa, 1975).

Tulbaghia transvaalensis Vosa.

TRANSVAAL—2330 (Tzaneen): on the top of Umkomani, Cyprus Farm, in red soil (-AD), 15-10-77, *Vosa* 1644 (OX).

ACKNOWLEDGEMENTS

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APPARENT TRANSPIRATIONAL RHYTHMS OF *AVICENNIA MARINA* (FORSK.) VIERH. AT INHACA ISLAND, MOÇAMBIQUE

T. D. STEINKE

(Department of Botany, University of Durban-Westville)

ABSTRACT

The potometric method was used to investigate the apparent transpirational rhythms of *Avicennia marina* (Forsk.) Vierh. in the Ponta Rasa mangrove swamp on Inhaca Island. The increase in transpiration rate to a maximum at 10h00, followed by a steady decrease, confirmed findings by other workers. However, inundation of mangroves by a spring tide did not reverse the decrease in rate during the late afternoon. Mangroves growing in a "dry" area inundated only during spring tides and in a "wet" area in which moisture was freely available to the trees showed no differences in apparent transpiration rhythm.

UITTREKSEL

SKYNBARE TRANSPIRASIERITMES VAN *AVICENNIA MARINA* (FORSK.) VIERH. OP INHACAEILAND, MOSAMBIEK.

Die potometriesie tegniek is gebruik om die skynbare transpirasieritme van *Avicennia marina* (Forsk.) Vierh. in die Ponta Rasa wortelboommoeras op Inhacaeiland te ondersoek. Die toename in transpirasietempo tot 'n maksimum om 10h00, gevolg deur 'n stadige afname, is ook deur ander navorsers vasgestel. Oorstrooming van die wortelbome deur 'n springetide het nie 'n omkeer in die afname van die transpirasietempo in die laat namiddag tot gevolg gehad nie. Daar was geen verskil in die transpirasietempo van bome in 'n "droë" gebied wat slegs tydens springetide oorstroom word, en die bome in 'n "nat" gebied waar vogtigheid altyd vryelik beskikbaar was nie.

INTRODUCTION

This research was conducted to provide more information on the pattern of transpiration in *Avicennia marina* which is probably the commonest of the mangroves occurring along the coast of Southern Africa. A previous study (Lewis & Naidoo, 1970) had been conducted during one of the cooler months of the year in Southern Africa, and it was felt that, for a more complete understanding, data for the hot summer months were necessary as well. For this reason a series of readings was conducted on Inhaca Island, Mocçambique, in January, 1974. Although this study confirmed the general pattern of transpirational rhythm which had been established previously, the rate was not influenced by the ready availability of free water for transpiration.

MATERIAL AND METHODS

The study was conducted in the Ponta Rasa mangrove swamp which was described by Mogg (1963). Young, healthy trees 2 to 3 m tall, bearing immature propagules, were used in this investigation. The ground vegetation comprised *Arthrocnemum* spp. and *Chenolea diffusa*.

The potometric method described by Lewis & Naidoo (1970), was used to determine apparent transpirational rhythm. Wherever possible, values represent the mean of readings obtained from two potometers, each attached to adjacent trees. Readings were taken on the hour, usually every hour, from 06h00 until 18h00, i.e. from just after sunrise until just before sunset. An exception was made in the experiment conducted on 24 January, when readings until 14h00 were taken at two-hourly intervals. Temperature and humidity measurements were obtained with a whirling psychrometer simultaneously with transpirational readings. The weather during the entire experimental period was hot with very little wind. There was no cloud except on 22 January, when temperatures were also slightly lower, and on 24 January when intermittent slightly overcast conditions were experienced.

In order to determine the effect of a late afternoon tidal inundation, one set of readings (24 January) was taken during spring tides. At high tide the base of the trees was inundated to a depth of 50 mm.

A comparison of transpiration rate between "wet" and "dry" sites was conducted with trees 40 m apart. The trees in the "wet" areas were growing in mud inundated frequently at high tide. The receding tide left the soil waterlogged with puddles on the surface. The salinity of the water in these puddles was approximately 30% apparently as a result of showers of rain. Moisture was thus freely available to the mangroves growing in this area. The trees in the "dry" areas were growing in mud overlain by sand and were inundated only during high spring tides.

RESULTS

Results revealed that the rate of transpiration increased until 10h00, after which there was a steady decrease (Fig. 1). However, variations from this pattern did occur as in one set of readings (22 January) there was a more gradual increase in rate which reached a maximum only at 12h00 (Fig. 2). A high spring tide had no effect in reversing the decrease in the late afternoon (Fig. 3). There appeared to be no significant difference in transpiration rate between trees growing in "dry" and "wet" areas (Fig. 4), although the latter trees were subjected to shallow tidal coverage at approximately 14h00.

DISCUSSION

The results of this work confirmed the findings of other workers (Lewis & Naidoo, 1970; Leshem & Levison, 1972) that transpiration reached a mid-morning maximum at approximately 10h00, after which there was a steady decrease. Research by Joshi *et al.* (1974) indicated that stomata of several mangroves were wide open until 10h00 and that thereafter stomatal apertures decreased. Although these workers did not study *Avicennia marina*, it is possible that the same behaviour could be revealed, accounting for the steady decrease in transpiration during the late morning and afternoon. Under the extremely hot conditions

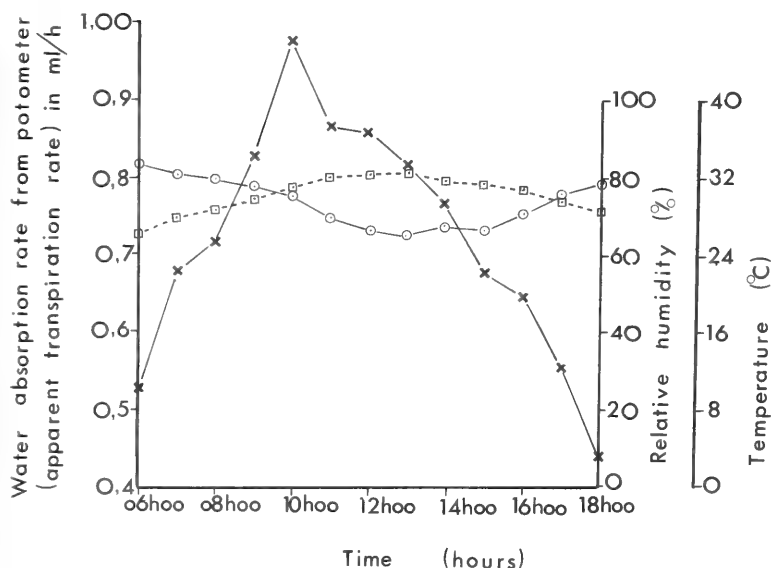


FIG. 1.

Mean relative humidities (○—○), temperatures (□—□), and apparent transpiration rates (x—x) of *Avicennia marina* on 16/1/1974. Neap tides, no tidal coverage, but water freely available in "wet" area.

prevailing at Inhaca in January, it would appear that the water potential gradient was so steep that the consequent high rate of transpiration induced an internal water deficit which resulted in the inception of stomatal closure. Although the significance of temperature was not unexpected, it was interesting to note the magnitude of its effect, for high temperature was of overriding importance. The water deficit induced by the high temperatures is obviously a very powerful regulator, as it caused stomatal closure even in bright light.

It is clear that after the inception of stomatal closure, the continuing high temperatures prevented stomatal re-opening even when water was freely available to the trees.

Lewis & Naidoo (1970) maintained that an incoming tide in the afternoon caused a temporary increase in transpiration, apparently as a result of the ready availability of water which enabled turgor to be regained and the stomata to open. The results at Inhaca showed no such temporary increase in transpiration rate with an incoming tide. The results on 20/1/1974 (Fig. 4), where a very shallow tidal coverage of trees in the "wet" area was experienced at approximately 14h00, did not reveal a significant increase at that time. This was not surprising as water had

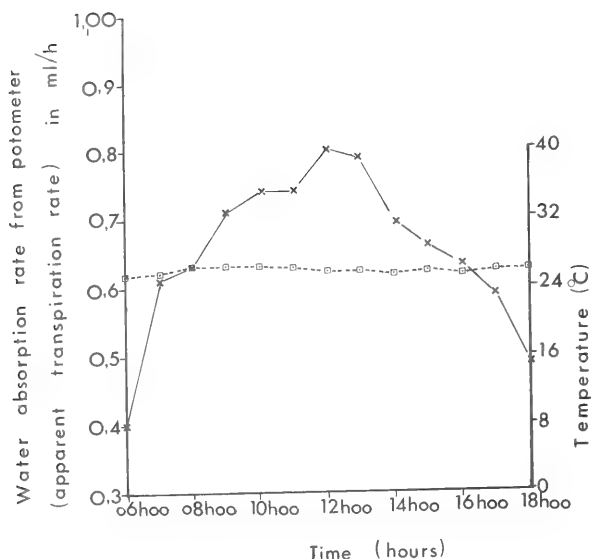


FIG. 2.

Mean temperatures (\square --- \square) and apparent transpiration rates (x — x) of *Avicennia marina* on 22/1/1974. Start of spring tides, but no tidal coverage of experimental plants.

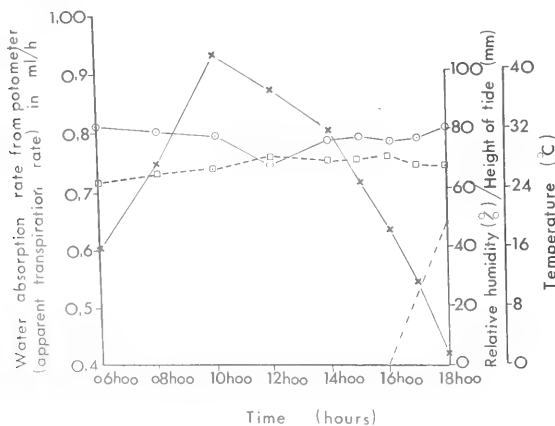


FIG. 3.

Mean relative humidities (\circ — \circ), temperatures (\square --- \square), tidal heights (----) and apparent transpiration rates (x — x) of *Avicennia marina* on 24/1/1974. Spring tides, tidal coverage of plants.

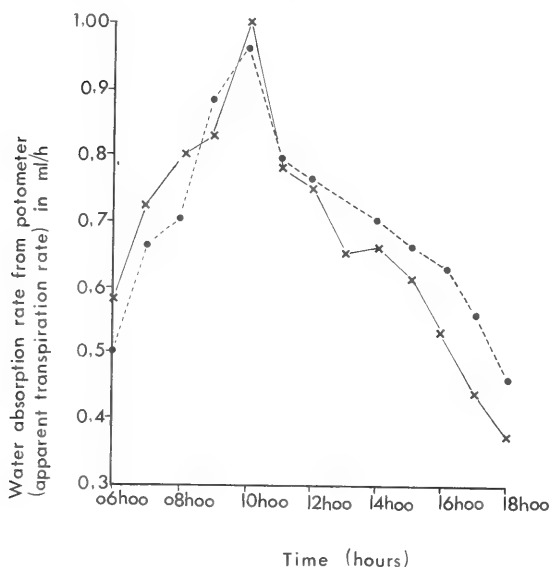


FIG. 4.

Mean apparent transpiration rates of *Avicennia marina* trees growing in a "wet" area (x — x) and in a "dry" area (● --- ●) on 20/1/1974. Shallow tidal coverage only in "wet" area.

been freely available to these mangroves prior to any tidal influence. The failure of an incoming tide to cause an increase in transpiration rate was further confirmed by the results on 24/1/1974 (Fig. 3). Although on the latter day tidal waters did not reach the mangroves until 16h00, sunset was at approximately 18h45, thus leaving at least three hours of daylight before darkness fell. During this period the rate of transpiration continued to decrease at a steady rate. On 14/5/1968 Lewis & Naidoo (1970) measured a tidal influence only at 15h30, while sunset on that day was soon after 17h00, i.e. only two hours elapsed between a perceptible tidal influence and darkness. In spite of this relatively short period, an increase in relative transpiration rate was still recorded by them. At Inhaca no increase in transpiration rate occurred when tidal inundation took place almost three hours before sunset. The lack of any effect due to freely available water was confirmed by the results obtained from plants growing in the "wet" and "dry" areas. Plants from both these areas revealed the typical pattern with no reversal of this trend being measured in the "wet" area.

It may be interesting to try to explain the reasons for the discrepancy between the results from Durban and Inhaca. Lewis and Naidoo (1970) suggested that in May stomatal closure commenced soon after 16h00 as tidal inundation later than

this time failed to prevent the decline in transpiration rate. It is difficult to believe in the light of evidence referred to earlier in this discussion that tidal inundation at Inhaca occurred too late on 24/1/1974 to prevent the decline in transpiration rate. Plants are unlikely to commence stomatal closure at a particular time throughout the year, rather might it be expected that plants would be able to compensate for daylength at different times of the year. Therefore, stomatal closure, in the absence of overriding factors such as high temperature which, it was suggested, caused early closing of stomata at Inhaca, would probably take place later in summer than in winter. Furthermore, the readings at Inhaca were obtained during January, probably the hottest month of the year, while the experiment at Durban was conducted during May which is one of the coolest months. Temperature recordings at Inhaca at that time of the year showed relatively little diurnal variation, reaching as much as 34 °C during the day. No temperature data are given for the period of the experiment conducted at Durban, but mean maximum and minimum temperatures for May are 24,2 °C and 12,9 °C respectively. Inhaca is closer by approximately 500 km to the Tropic of Capricorn than Durban Bay which is approaching the southernmost limit of mangroves in this country.

These results have indicated the need for more research on water relations in mangroves and for such work to be correlated if possible with observations on stomatal movements.

ACKNOWLEDGEMENTS

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THE ORIGIN OF THE BOUQUET ARRANGEMENT OF PROPHASE CHROMOSOMES IN *ALLIUM CEPA*

D. J. MOGFORD

(Department of Plant Sciences, Rhodes University, Grahamstown)

ABSTRACT

Using a denaturation-reannealing treatment to indicate the location of heterochromatin, it is shown that the bouquet arrangement of prophase chromosomes in *Allium cepa* is a consequence of the arrangement of chromosomes during interphase, which is itself derived from their arrangement at the previous telophase. The developmental implications of this are discussed.

UITTREKSEL

DIE OORSPRONG VAN DIE BOUQUET-RANGSKIKKING VAN DIE PROFASE CHROMOSOME IN *ALLIUM CEPA*

Deur gebruik te maak van 'n denaturasie-hervoeëing behandeling om die posisie van die heterochromatien aan te dui, word dit getoon dat die bouquet-rangskikking in die profase chromosome in *Allium cepa* die gevolg is van die rangskikking van die chromosome gedurende die interfase, wat weer die gevolg van die rangskikking van die voorafgaande telofase is. Die ontwikkelingsimplikasies hiervan word bespreek.

INTRODUCTION

Over the past few years, considerable evidence has accumulated to indicate that the arrangement of chromosomes in interphase nuclei is non-random. Of particular value has been the application of denaturation-reannealing techniques which, by indicating the location of heterochromatin, offer new opportunities for following the positions of specific chromosome regions throughout the mitotic cycle.

Using one such technique, Mogford (1977) demonstrated that in root tip nuclei of the onion, *Allium cepa*, chromosomes maintain throughout interphase the arrangement established at the previous telophase. This finding has since been confirmed by other workers (Fussel, 1977; Ghosh and Roy, 1977).

Little attention has so far been devoted to the significance of the various types of chromosome arrangement observed during the prophase stages of mitosis. For example, it has long been known that, in many species, the chromosomes on their first appearance at prophase are present in a bouquet-like arrangement. The origin of this arrangement has remained unknown.

The present work was designed to investigate the origin of the bouquet arrangement of chromosomes in prophase nuclei of *A. cepa*, using the denaturation-reannealing technique previously used with success in determining the interphase arrangement of chromosomes in this species.

MATERIAL AND METHODS

Investigations were performed on rapidly growing root tips of *Allium cepa* var. "White Lisbon". In some cases, the root tips were pre-treated by immersion in 0.5% colchicine solution for three hours at room temperature, in order to accumulate metaphase stages; in other cases, the root tips were not pre-treated, these preparations being used for studies of the complete course of mitosis.

In either case, the material was fixed in 3:1 ethanol:glacial acetic acid overnight, and hydrolysed in 0.2N HCl at 60 °C for 2½ minutes. The meristems were squashed in 45% acetic acid under an albumenised coverslip, the coverslip then being floated off in absolute alcohol, air-dried, and immersed in saturated barium hydroxide solution for 6 minutes at room temperature. The preparations were rinsed in running deionised water, incubated in 2 x saline sodium citrate buffer at 60 °C for 30 minutes, rinsed again in deionised water, air-dried and stained for 5 minutes in a 0.1% alcoholic solution of the DNA-binding benzimidazole derivative Hoechst 33258.

The material was then rinsed in absolute alcohol, air-dried, mounted in 50% glycerol and observed using a Zeiss fluorescence microscope with exciter filter BG12 and barrier filter 50. Photographs were taken using Kodak Tri-X Pan film.



FIG. 1.

Metaphase complement of *A. cepa* var. "White Lisbon", prepared as described in text. Brightly fluorescent regions indicate location of heterochromatin.

RESULTS

The chromosome complement of *A. cepa* var. "White Lisbon" is shown in Figure 1. It may be seen that heterochromation is present on all the chromosomes and is almost exclusively terminal in position. The distribution of heterochromatin in this variety therefore appears identical to that in variety "Ailsa Craig" (Mogford, 1977).

The positions of the heterochromatic segments at the various stages of mitosis are illustrated in Figures 2-9. The typical bouquet arrangement of chromosomes referred to above is illustrated in Figure 3.

From comparisons of the positions of the heterochromatic segments at the various stages it may be seen that the bouquet arrangement of chromosomes is derived from the interphase arrangement of chromosomes described previously (Mogford, 1977) and illustrated in Figure 9. During interphase the chromosomes maintain the telophase arrangement of the previous mitosis, with telomeres grouped towards one side of the nucleus and centromeres towards the other.

The onset of prophase is marked by a contraction and loosening of the chromosomes (Fig. 2) to form the bouquet arrangement (Fig. 3), during which

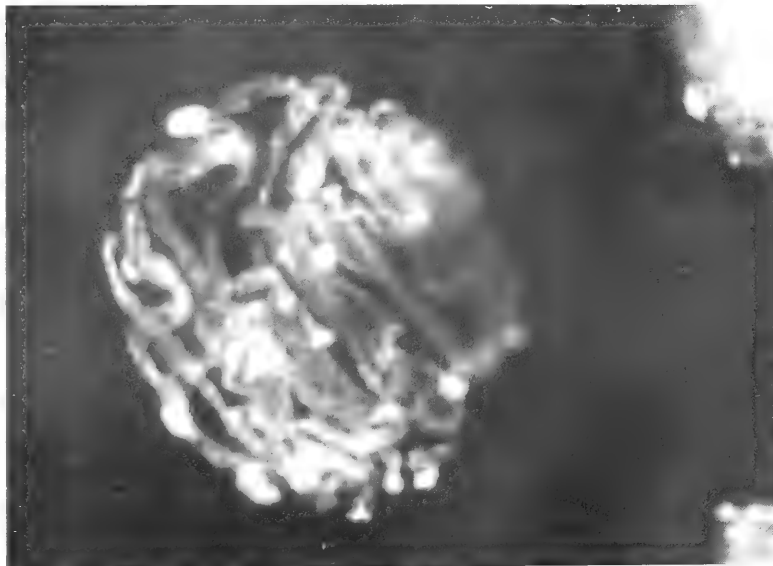


FIG. 2.
Early prophase.

FIGS 2-9.
The course of mitosis in *A. cepa* var. "White Lisbon".

stages the interphase polarisation of telomeres towards one side of the nucleus remains obvious. Continued contraction of the chromosomes occurs (Figs 4, 5) until the typical late prophase appearance is reached (Fig. 6), at which stage no obvious arrangement of the chromosomes remains. A regular arrangement, however, is evident at the succeeding metaphase and anaphase stages (Figs 7, 8), and by late telophase the daughter nuclei show the polarisation of heterochromatic segments typical of interphase (Fig. 9).

DISCUSSION

The results indicate that the bouquet arrangement of prophase chromosomes in *Allium cepa* is a direct consequence of their ordered arrangement in the interphase nuclei, which is in fact itself determined by their arrangement at the preceding telophase.

The maintenance of the ordered arrangement of chromosomes throughout interphase may be related to the occurrence of end-to-end fusions of the heterochromatic regions in this species (Mogford, 1977); however, the significance of such fusions remains obscure, despite confirmation of their existence by Fussel (1977).

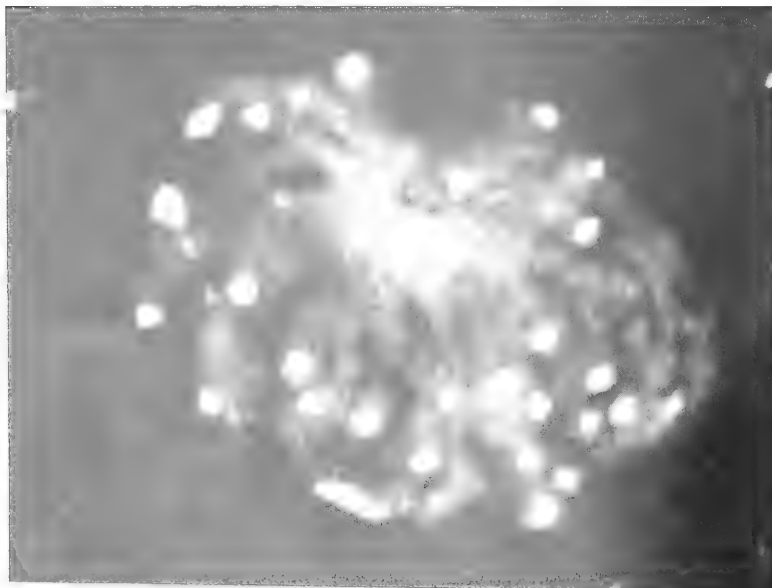
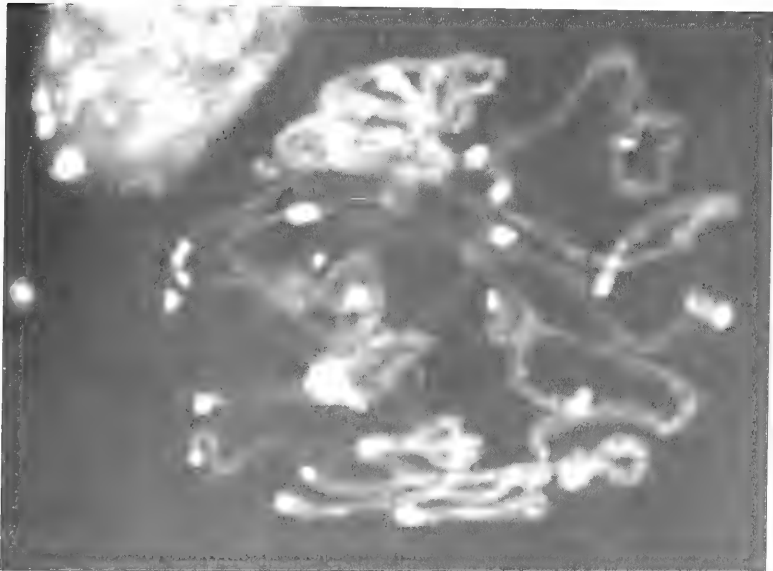


FIG. 3.
Prophase bouquet arrangement.



FIGS 4-5.
Mid prophase.

An interesting consequence of the occurrence of fixed chromosome arrangements in interphase is the possibility that the plane of division of the nuclei may be determined by the orientation of the chromosomes. If this is the case, then the fixed arrangement of chromosomes, which extends at least from metaphase until the succeeding late prophase, must considerably reduce the number of planes of division available to the cell. If the fixed arrangement of chromosomes persists throughout late prophase as well, which is a possibility despite the haphazard arrangement of chromosomes at this stage revealed by the present technique, then the possible planes of cell division would be reduced still further.

Since the precise planes at which cell divisions occur is a crucial factor in development (Davidson, 1968), it is evident that further studies of mitotic chromosome arrangements may be of considerable significance in relation to the control of development.

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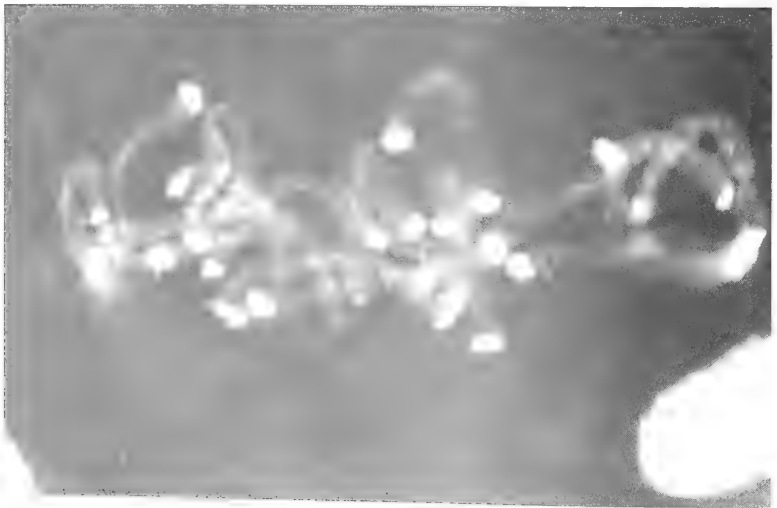


FIG. 6.
Late prophase.



FIG. 7.
Metaphase.



FIG. 8.
Anaphase.

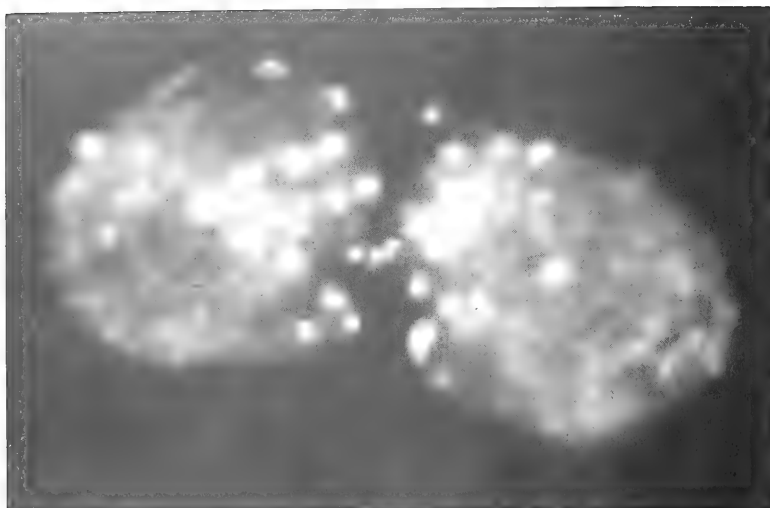


FIG. 9.
Late telophase.

STUDIES IN THE GENERA OF THE *DIOSMEAE* (RUTACEAE): 8

ION WILLIAMS

(Honorary Reader, Bolus Herbarium, University of Cape Town
Honorary Research Worker, Compton Herbarium, Kirstenbosch)

ABSTRACT

Three new species of *Euchaetis*, three new species of *Acmadenia* and four new species of *Diosma* are described.

UITTREKSEL

STUDIES IN DIE GENERA VAN DIE *DIOSMEAE* (RUTACEAE): 8

Drie nuwe *Euchaetis* soorte, drie nuwe *Acmadenia* soorte en vier nuwe *Diosma* soorte word beskryf.

Euchaetis cristagalli Williams, sp. nov. earum foliis lineari-lanceolatis propria propter petala longissimas mox deciduas.

Frutex 0,3-0,5 m, latus, diffusus, ad basim monocalis. *Rami* teretes, laxi, graciles, pauci, dichotomi, glabrescenti. *Ramuli* pauci, erecti, gracilliores, rubescens, puberuli. *Folia* 6-19 mm longa, 1-1,3 mm lata, lineari-lanceolata, acuta, mucronata, breve petiolata, glabra, alterna, glanduloso-punctata, marginibus anguste hyalinis minute ciliolato-serrulatis. *Inflorescentia* 7,5 mm diam., terminalia, pauci-aggregata. *Bractea* 1,3-3,7 mm longa, 0,6-0,9 mm lata, oblonga, obtusa, glabra, mucronulata, glanduloso-punctata, marginibus hyalinis ciliolato-serrulatis. *Bracteolae* duae, 1,1 mm longae, 0,5-0,6 mm latae, ellipticae, obtusae, glabrae, mucronulatae, glanduloso-punctatae, marginibus late hyalinis ciliolatis. *Sepala* quinque, 2,5 mm longa, 1,2-1,3 mm ad basim lata, lanceolata, obtusa, mucronulata, glabra, multi-glanduloso-punctata, marginibus late hyalinis. *Petala* quinque, 5,5 mm longa, mox decidua; *limbus* 3,5 mm longus, 1,8 mm latus, ellipticus, sub-acute, niveus, patens; *unguis* 2 mm longum, 1,1 mm latum, forte transverse barbatum, ciliatum. *Staminodia* quinque, minutis tumulis deminuta. *Fila* quinque, 1,3 mm longa, glabra. *Antherae* quinque, ante anthesin 1,1 mm longae, 0,75 mm latae, vinosae, glandula coronata. *Pollen* 50 μ longum, 21 μ latum, oblongum. *Discus* viridus, succulentus, ovarium obvallens, nectarifer. *Stigma* 0,35 mm diam., capitatum, viridum. *Stylus* 1,3 mm longus, erectus, glaber. *Ovarium* 5-carpellatum, 0,6 mm longum, 0,6 mm diam., glabrum. *Fructus* 5-carpellatus, 5,5-6,5 mm longus, 4,3 mm diam., glaber, viridus, minute glanduloso-punctatus; *cornua* 1 mm longa, erecta. *Semen* 3,5-3,8 mm longum, 1,6-1,8 mm latum, piceum, nitens.

Type: CAPE—3324 (Steytlerville): east of Cockscomb, Great Winterhoek Mtns., Uitenhage Division (-DB), 915–975 m (3 000–3 200 ft.) alt., 9/3/1977, *Williams 2283* (NBG, holotype; BOL, K, L, MO, PRE, S, STE, isotypes).

This plant was discovered by Miss Elsie Esterhuysen in 1957. She deserves all praise for noticing such an insignificant little shrub; one which could so easily be overlooked by any other collector. Her contribution to our knowledge of Cape plants must forever outshine that of all our other great botanical collectors.

Shrubs 0,3–0,5 m tall, lax and somewhat diffuse in low fynbos, arising from a single stem at ground level. *Branches* terete, lax, slender, few in number, dichotomous, reddish-brown, becoming glabrous with the cuticle splitting off. *Branchlets* few in number, erect, very slender, reddish-brown, puberulous, not hidden by the leaves. *Leaves* 6–19 mm long (mostly \pm 9 mm), 1–1,3 mm broad, linear-lanceolate, acute, mucronate, short-petiolate, glabrous, alternate, adpressed-erect, erect or on low shoots spreading; margins narrowly translucent, minutely ciliolate-serrulate; adaxial surface concave; abaxial surface convex, gland-dotted on either side of the midrib. *Inflorescence* terminal, solitary, on much reduced branchlets crowded together into small groups. *Bract* 1,3–3,7 mm long, 0,6–0,9 mm broad, asymmetrically oblong, obtuse, glabrous; apex with a small blunt mucro; margins translucent, in part minutely ciliolate-serrulate; abaxial surface gland-dotted to either side of the midrib. *Bracteoles* two, 1,1 mm long, 0,5–0,6 mm broad, elliptic, obtuse, glabrous; apex with a minute blunt mucro; margins broadly translucent, minutely ciliolate; abaxial surface minutely gland-dotted. *Calyx lobes* five, 2,5 mm long, 1,2–1,3 mm broad at the base, lanceolate, glabrous; apex somewhat obtuse with a minute reddish mucro; margins broadly translucent, minutely ciliolate; abaxial surface with numerous minute gland dots to either side of the midrib. *Petals* five, 5,5 mm long, white, spreading 7,5 mm diam., soon falling away; *limb* 3,5 mm long, 1,8 mm broad, elliptic, sub-acute, abaxial surface obscurely gland-dotted to either side of the midrib; *claw* 2 mm long, 1,1 mm broad, somewhat translucent, strongly transversely bearded, ciliate. *Staminodes* five, reduced to a minute swelling \pm 0,2 mm diam., on the outer surface of the disc at the base of the petal. *Filaments* five, becoming 1,3 mm long, acicular, glabrous, incurved erect. *Anthers* five, before anthesis 1,1 mm long, 0,75 mm broad, wine-coloured with a minute globose gland clasped at the apex. *Pollen* 50 μ long, 21 μ broad, oblong. *Disc* dark green, fleshy, level on top, surrounds and exceeds the ovary but does not close over it at first. *Stigma* 0,35 mm diam., capitate, globose, green. *Style* erect, glabrous, becoming 1,3 mm long. *Ovary* 5-carpellate, 0,6 mm long, 0,6 mm diam., glabrous; *carpels* with globose apices. *Fruit* 5-carpellate, 5,5–6,5 mm long, 4,3 mm diam., glabrous, green, minutely gland-dotted, becoming striate veined when dry; *horns* 1 mm long, erect. *Seed* 3,5–3,8 mm long, 1,6–1,8 mm broad, black, shining; aril encased in black.

SPECIMENS EXAMINED

CAPE—3324 (Steytlerville): Cockscomb, Great Winterhoek Mts., Uitenhage

Div. (-DB), rocky E. slopes, 2 000–4 000 ft., 3/3/1957, *Esterhuysen* 27156 (BOL); ridge on N. slopes, 4 000 ft., 2/2/1958, *Esterhuysen* 27539 (BOL); E. of Cockscomb, Great Winterhoek Mts., Uitenhage Div., S. facing T.M.S. slopes on Forestry track above Elandskroon farm, 915–975 m (3 000–3 200 ft.) alt., 9/3/1977, *Williams* 2283 (NBG, BOL, K, L, MO, PRE, S, STE).

—3325 (Port Elizabeth): Great Winterhoek Mtns., Groot Plaat 282, Uitenhage Div. (-CA), S.E. exposure, 2 450 ft., 1/3/1974, *Scharf* 1182 (PRE).

DISTRIBUTION AND BIOLOGY

Euchaetis cristagalli has been found growing on quartzitic stony soil in low fynbos in which *Leucadendron loeriense* Williams forms a conspicuous element, in the Great Winterhoek Mountains from the Cockscomb eastwards towards the Strydomsberg, a distance of about 33 kilometres, at altitudes of between 610 and 1 220 m above sea level. This range, consisting of rocks of the Table Mountain Series, forms a spur at the easternmost end of the Cape folded belt. No other plant in the genus *Euchaetis* is to be found any further to the east. In early March when the type collection was made plants were found bearing buds, flowers and ripe fruits so one may deduce that flowering may commence as early as December and that fruiting may still be taking place as late as May. The relatively large petals and the nectariferous disc would indicate that this plant is pollinated by insects. Regeneration appears to take place from seed after fires. The leaves when crushed give off a very faint mouldy smell.

DISCUSSION

The one character that places this plant in the genus *Euchaetis* is the possession of transversely bearded petals. This pubescence forms a screen beneath which the reproductive parts of the flower are effectively concealed. Other characters that also exclude it from other genera of the *Diosmeae* are: (1) *flowers* terminal in reduced racemes; (2) *staminodes* vestigial; (3) *anther* with a minute apical gland; (4) *disc* exceeds the ovary as a vertical wall; (5) *stigma* capitate; (6) *style* and *filaments* short and glabrous; (7) *ovary* 5-carpellate.

Euchaetis cristagalli is most easily recognised as distinct from other species of *Euchaetis* with linear-lanceolate leaves because of its having the longest petals. It has been observed that these petals very readily fall away. *E. cristagalli* may be distinguished from *E. elata* which has leaves sessile, pubescent on the adaxial surface and flowers sessile \pm 3-nate with the style at some time deflexed; from *E. glomerata* which has broader leaves and smaller flowers in multi-florous heads; from *E. flexilis* which has leaves with sacculate apices and broad translucent margins. It is perhaps nearest in appearance to *E. linearis* which however has leaves with only two rows of gland dots, flowers in many flowered heads with small petals and a disc that stands open, not obvallate. The name refers to the locality where this plant occurs.

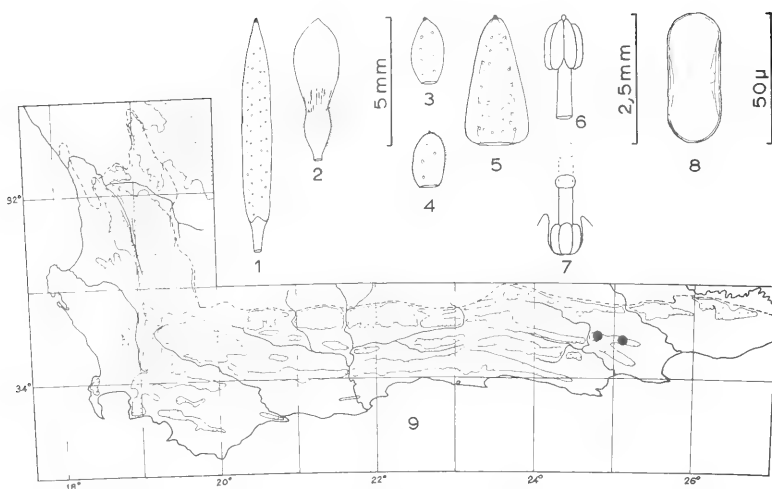


FIG. 1

Euchaetis cristagalli: 1, leaf. 2, petal. 3, bract. 4, bracteole. 5, calyx lobe. 6, anther. 7, gynoecium and disc. 8, pollen. 9, distribution.

***Euchaetis esterhuysenae* Williams, sp. nov.** propria propter folia parva ovata sessilia alterna patentia, flores parva.

Frutex 0,6 m altus, 2 m diam., densus, ad basim monocaulis. *Rami* numerosi, patentes, rigidi, graciles, flexuosi, saepe dichotomi; *cortex* aspera, cinerea. *Ramuli* brevi, graciles, erecti, dichotomi, rubescenti, sparsim puberuli vel glabri. *Folia* 2,2–3,2 mm longa, 1,5–2 mm lata, ovata, obtusa, obtusa-mucronata, glabra, glanduloso-punctata, crassa, sessilia, alterna, patentia, marginibus crassis, anguste hyalinis, minute serrulatis. *Inflorescentia* terminalia; *flores* 3,3 mm diam., sessiles, reducto-racemosi. *Bractea* 1,5–2,8 mm longa, 1–1,5 mm lata, elliptica, obtusa, rubro-callosa, crassa, glabra, sparsim glanduloso-punctata, marginibus minute serrulatis. *Bracteolae* duae, 1–1,3 mm longae, 0,6–0,8 mm latae, ellipticae, obtusae, rubro-callosae, glabrae, sparsim glanduloso-punctatae, marginibus hyalinis ciliolatis. *Sepala* quinque, 1,5–1,8 mm longa, 1–1,4 mm lata, oblonga, obtusa, rubro-callosa, sparsim glanduloso-punctata, intus pubescentia, marginibus late hyalinis, ciliolatis. *Petala* quinque, 2,5–3 mm longa, alba, erecta deinde parum patentia; *limbus* 1,2 mm longus, 1,2 mm latus, transverse barbatus, sparsim ciliatus, costa villosa. *Staminodia* quinque, 0,1–0,2 mm longa. *Fila* quinque, 1,2 mm longa, glabra, subulata. *Antherae* ante anthesin 1 mm longae, 0,7 mm latae, vinosae, glandula 2 mm diam., coronata. *Pollen* 45 μ longum, 23 μ latum, oblongum. *Discus* obvallatus, nectarifer, vinosus. *Stigma* 0,2 mm diam., capitatum, globosum, viridum. *Stylus* primus deflexus deinde erectus, 1,2 mm

longus, glaber. *Ovarium* 5-carpellatum, 0,6 mm diam., glabrum. *Fructus* 5-carpellatus, 7,5 mm longus, 6,5 mm diam., glaber, nitens, vinosus, multi-glanduloso-punctatus; *corna* 1,5 mm longa. *Semen* 4,7 mm longum, 2–2,2 mm latum, piceum, nitens.

Type: CAPE—3219 (Wupperthal): ridge S.E. of Bloukop, E. Cold Bokkeveld, Ceres Div. (-CB), 1 450–1 550 m (4 800–5 000 ft.) alt., 18/5/1977, Williams 2304 (NBG, holotype; BOL, K, L, MO, PRE, S, STE, isotypes).

Euchaetis esterhuysenae is appropriately named in honour of Miss Elsie Esterhuysen of the Bolus Herbarium because, out of the twenty times that it has been collected, thirteen are hers. She discovered this species in March 1940 on the summit of the Suurvleisberg, a most daunting mountain peak. Subsequently it was also collected a few times by T. Stokoe.

Shrubs 0,6 m tall, 2 m diam., with many branches spreading from the base at ground level, forming a dense wiry shrub; *wood* yellow in colour. *Branches* numerous, spreading, rigid, fairly slender, flexuose, often dichotomous; bark rough, grey. *Branchlets* short, slender, erect, dichotomous or single by abortion, reddened, thinly puberulous, not hidden by the leaves. *Leaves* 2,2–3,2 mm long, 1,5–2 mm broad, ovate, apex sacculate when dry, obtuse with a blunt sometimes reddened callus, fleshy, glabrous, sessile, spreading, alternate; margins thick, narrowly translucent, minutely serrulate; abaxial surface gland-dotted to either side of the midrib. *Inflorescence* terminal, 3,3 mm diam., flowers white, sessile in reduced racemes, the uppermost being the latest to bloom. *Bract* 1,5–2,8 mm long, 1–1,5 mm broad, elliptic, obtuse, red-callused, fleshy, glabrous, sparingly gland-dotted, margins minutely serrulate. *Bracteoles* two, 1–1,3 mm long, 0,6–0,8 mm broad, elliptic, obtuse, red-callused, glabrous, sparingly gland-dotted, margins translucent, ciliolate. *Calyx lobes* five, 1,5–1,8 mm long, 1–1,4 mm broad, oblong, obtuse, red-callused, sparingly gland-dotted, margins minutely serrulate above, translucent and ciliolate below, adaxial surface pubescent. *Petals* five, 2,5–3 mm long, white, at first erect, later spreading slightly and readily falling away; *blade* 1,2 mm long, 1,1 mm broad, elliptic, obtuse; *claw* 1,8 mm long, 1,2 mm broad, narrowing to the base, transversely bearded above with strong thick hairs, margins sparsely ciliate, midrib villous. *Staminodes* five, vestigial, 0,1–0,2 mm long, on the outer edge of the disc. *Filaments* five, becoming 1,2 mm long, glabrous, subulate. *Anthers* five, 1 mm long, 0,7 mm broad, wine-coloured, apical gland 2 mm diam., pale, globose, inclined inwards. *Pollen* 45 μ long, 23 μ broad, oblong. *Disc* equalling or slightly exceeding the ovary, erect and level all round, wine-coloured, exudes nectar. *Stigma* 0,2 mm diam., capitate, globose, green. *Style* at first deflexed becoming erect, 1,2 mm long, glabrous. *Ovary* 5-carpellate, 0,6 mm diam., glabrous. *Fruit* 5-carpellate, 7,5 mm long, 6,5 mm diam., glabrous, shining, wine-coloured, with many gland

dots; horns 1.5 mm long, darker in colour with an immersed apical gland. Seed 4.7 mm long, 2–2.2 mm broad, black, shining; endosperm not conspicuous.

SPECIMENS EXAMINED

CAPE—3219 (Wupperthal): Cedarberg Mtns., Krakadouwsberg, Clanwilliam Division (-AA), 30/12/1941, *Esterhuysen* 7497 (BOL, SAM, NBG), 6 000 ft., 22/9/1942, *Esterhuysen* 8054 (BOL); N. Cedarberg Mtns., rocky summit of Great Krakadouw Peak, 5 700 ft., 20/11/1945, *Esterhuysen* 12100 (BOL), -/1/1942, *Stokoe s.n.* (SAM 59345); summit of the Suurvelisberg (Suurvlaksekop) (-AC), 5 300 ft., -/3/1940, *Esterhuysen* 2555 (BOL, NBG); Cedarberg Mtns., Langeberg, 6 000 ft., 15/12/1941, *Esterhuysen* 7357 (BOL, NBG), 5 800 ft., 15/12/1973, *Williams* 1768 (NBG); Cedarberg Mtns., rocky slope below Tafelberg, 5 000 ft., 27/12/1947, *Esterhuysen* 14347 (BOL); Cedarberg Mtns., Uityk Peak, 16/12/1941, *Esterhuysen* 7382 (BOL); ledge on S. side below summit of Olifants River Dome, 5 000 ft., 16/4/1949, *Esterhuysen* 15286 (BOL); Donkerkloof Peak near Citrusdal, Clanwilliam Division (-CA), -/1/1945, *Stokoe* 9142 (BOL); Top of Hexberg, Clanwilliam Division, -/3/1951 *Stokoe s.n.* (SAM 66817); S. Cedarberg Mtns., Clanwilliam Division, rocks on Sneeuwberg, 6 000 ft., 1/3/1947, *Esterhuysen* 13835 (BOL); Elands-kloof N. side on summit of peak, Clanwilliam Division, 3/10/1940, *Esterhuysen* 3194 (BOL); S. Cedarbergen, Apollo Peak, rocky slopes, 4 500–5 000 ft., 13/12/1950, *Esterhuysen* 18040 (BOL); S. Cedarberg, peak between Gideonskop and Sandfonteinberg, Ceres Division (-CB), 5 000 ft., -/4/1947, *Stokoe s.n.* (SAM 64152); S. Cedarberg, Gideonskop, Ceres Division, rocky kop, 4 500 ft., 6/4/1947, *Esterhuysen* 13886 (BOL); Blaauw-kop, E. Cold Bokkeveld, Ceres Division, rocky plateau and amongst rocks, 1/10/1958, *Esterhuysen* 27900 (BOL); S.E. ridge, 5 000 ft., 24/10/1975, *Williams* 2121 (NBG); 4 800–5 000 ft., 18/5/1977, *Williams* 2304 (NBG, BOL, K, L, MO, PRE, S, STE).

DISTRIBUTION AND BIOLOGY

Euchaetis esterhuysenae is found only near or at the summits of the highest mountains of the Cedarberg and the Northern Cold Bokkeveld from the Krakadouberg in the north to Bloukop in the south, a distance of about 63 km. It grows in rocky places rooted in crevices amongst quartzitic sandstone rocks of the Table Mountain geological series. Most plants seen are very old not having been burnt for many years. A section through the stem of one plant, 15 mm in diameter, showed at least 50 annual growth rings. Plants are also extremely slow-growing. A branch from one plant about 1 m long showed about 53 annual growth increments, making a growth rate of less than 20 mm per year. From the collections made it would appear that *E. esterhuysenae* is in bloom at least from December to May and that fruits may be found from May to October. The observed presence of nectar and the lengthening of the style after the pollen has been shed would indicate that this plant is most probably pollinated by insects. From the appearance

of the plant, regeneration can only take place from seed which is ejected by the usual catapult mechanism when ripe. Young plants may have leaves up to 5 mm long and 3,5 mm broad. Leaves have almost no smell at all when crushed.

VARIATION

Branchlets from plants in the Bloukop area appear to be very thinly puberulous whereas those from other populations are completely glabrous. Also plants with smaller leaves have fewer gland dots but this may be merely a factor of leaf size. Although growing in close association with *Euchaetis elsieae* on Bloukop no hybrids have been observed.

DISCUSSION

The presence of transversely bearded petals places this plant in the genus *Euchaetis*. Other factors which help to exclude it from other genera of the *Diosmeae* are: (1) flowers terminal in reduced racemes; (2) staminodes vestigial; (3) anthers with a small apical gland; (4) disc exceeds the ovary but does not close over it; (5) stigma capitellate; (6) style and filaments short and glabrous; (7) ovary 5-carpellate.

Euchaetis esterhuysenae is recognised as distinct having leaves small, ovate, glabrous, sessile, alternate and spreading, and small flowers with petals that soon fall away.

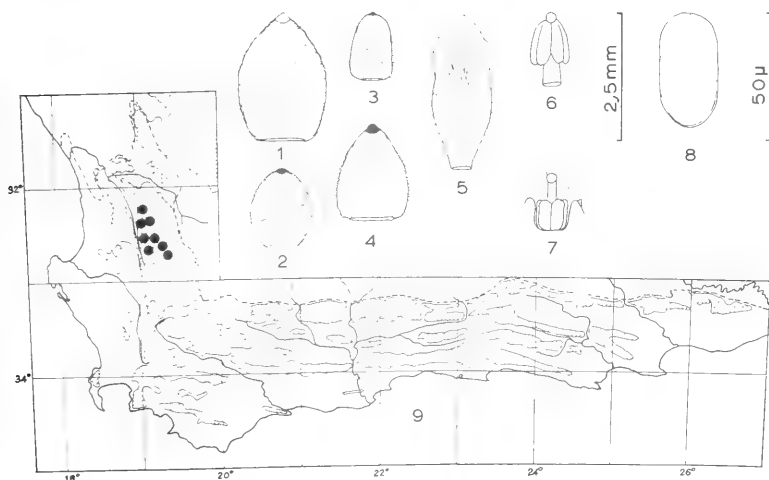


FIG. 2

Euchaetis esterhuysenae: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium and disc. 8, pollen. 9, distribution.



FIG. 3
Euchaetis esterhuysenae: 1, flower with petals erect at anthesis.

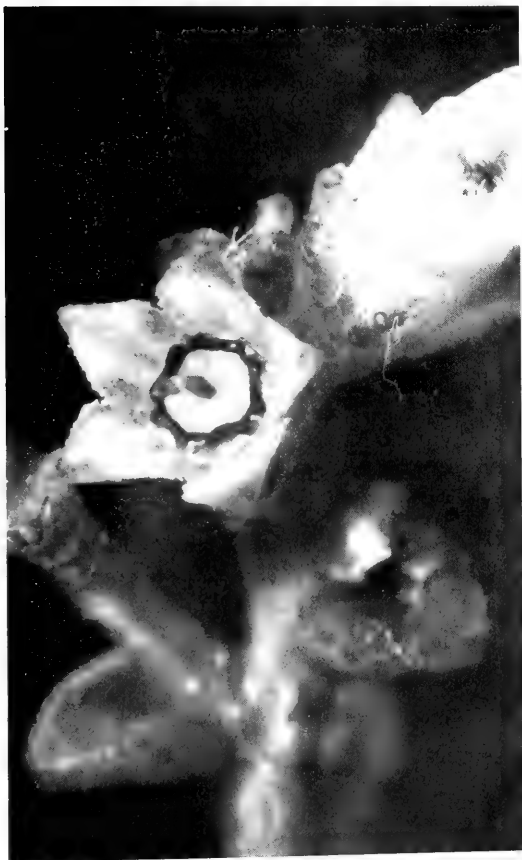


FIG. 4

Euchaetis esterhuysenae: Flower with petals delapsed showing the red disc.

Euchaetis vallis-simiae Williams, sp. nov. propria propter folia scabro-tomentosa, post apices conspicue gibbosos, stylum erectum, stigma 0,7 mm diam. capitatum.

Frutex ad 1,20 m, erectus, ad basim monocaulis. *Rami* erecti, recti, puberuli, rubescenti. *Ramuli* erecti, puberuli, foliosi. *Folia* 5–8 mm longa, 2,5–2,8 mm lata, elliptica, tota scabro-tomentosa, alterna, sub-imbricata, ad basim adpressa, petiolata, post apices conspicue gibbosi, forte costata, glanduloso-punctata. *Inflorescentia* terminalia, 1–4 nata; *calyx* tomentosus; *flos* 7 mm diam., sessilis. *Bractea* 4,8–5 mm longa, 2–2,2 mm lata, sub-ovoidea, tota scabro-tomentosa, petiolata, post apex gibbosus, forte costata, ciliata, pauci glanduloso-punctata. *Bracteolae* duae, 4,5 mm longae, 1–1,2 mm latae, oblanceolatae, obtusae, tota scabro-tomentosae, post apices conspicue gibbosae, pauci glanduloso-punctatae, ciliatae, marginibus anguste hyalinis. *Sepala* quinque, 3,1–3,3 mm longa, 2–2,2 mm lata, sub-quadrangularia, tota scabro-tomentosa, ciliata, post apices conspicue gibbosi, marginibus anguste hyalinis. *Petala* quinque, 5,6 mm longa; *limbus* 2,1 mm latus, ovatus, ad apice sub-emarginatus et pauci ciliatus, extus tomentosus; *unguis* 1,4 mm latus, forte transverse-barbatus, ciliatus. *Staminodia* quinque, 0,15 mm longa, vestigialia. *Fila* quinque, 1,6 mm longa, glabra. *Anthera* quinque, ante anthesin 1,2 mm longa, 1 mm lata, flava, glandula coronata. *Pollen* 41 μ longum, 30 μ latum, ellipsoideum. *Discus* viridus, succulentus, nectarifer, super ovarium parum cingens. *Stigma* 0,7 mm diam., capitatum, depresso-globosum, viridum. *Stylus* 1,5 mm longus, erectus, glaber, persistens. *Ovarium* 5-carpellatum, 0,7 mm longum, 1 mm diam., carpella ad apices tomentosa. *Fructus* 5-carpellatus, 9 mm longus, 6 mm diam., tota tomentosa; *cornua* 2,5 mm longa, sub-erecta, obtusa. *Semen* 5,5–6 mm longum, 2–2,5 mm latum, piceum, nitens.

Type: CAPE—3323 (Willowmore): Baviaanskloof Forest Reserve at Studtis, on forestry road at end of first plateau (-DB), 915 m (3 000 ft.) alt., 12/10/1976, Williams 2224 (NBG, holotype; AD, B, BOL, K, L, M, MO, NSW, PRE, S, STE, isotypes).

In going through the *Diosmeae* in the Fourcade Herbarium (BOL) I came across a plant, obviously different from any that I had seen in any other herbarium. collected by F. S. Laughton in 1933 at "The Fountains", Forest Reserve, Humansdorp. After enquiring at Humansdorp without success I eventually discovered from the Forestry Department at Knysna that "The Fountains" was on the north side of the Baviaanskloof Mountains near Wolvekraal, south of Steytleville. But before being able to visit this remote locality, I encountered, amongst the *Acmadenia* incertae at the Compton Herbarium, a collection of the same species by H. C. Taylor made in 1953. With the aid of precise directions from Mr Hugh Taylor, of the Botanical Research Unit at Stellenbosch, I was able to collect this plant with the greatest of ease near Studtis in the Baviaanskloof. The Forester there informed me that he knew the species well and that it was even more abundant on the north side of the Baviaanskloof Mountains.

Shrubs to 1,20 m, erect, single-stemmed at base, not forming a dense bush. *Branches* erect, straight, puberulous, somewhat reddened, slightly roughened by leaf scars, arising more or less in clusters. *Branchlets* fairly short, erect, puberulous, well clothed with leaves but not hidden, light green at first, tending to arise in clusters at all heights in the plant. *Leaves* 5–8 mm long including the petiole 1 mm long, 2,5–2,8 mm broad, elliptic, conspicuously gibbous behind the apex, at base adpressed erect, sub-imbricate, alternate, scabro-tomentose on all sides and margins with erect tapering hairs, midrib prominent with minute gland dots to either side. *Inflorescence* terminal, 1–4 nate; *calyx* puberulous; *flowers* 7 mm diam., sessile, white. *Bract* 4,8–5 mm long, 2–2,2 mm broad, sub-ovoid, scabro-tomentose on all sides, minutely gland-dotted, petiolate, apex reddened and gibbous on the outside, margins ciliate, midrib prominent. *Bracteoles* two, 4,5 mm long, 1–1,2 mm broad, oblanceolate, obtuse, scabro-tomentose on both sides, strongly ciliate, minutely gland-dotted, apex gibbous on the outside, margins narrowly translucent, midrib prominent. *Calyx lobes* five, 3,1–3,3 mm long, 2–2,2 mm broad, sub-quadrangular, scabro-tomentose on both surfaces, ciliate, margins narrowly translucent, apex gibbous on the outside. *Petals* five, 5,6 mm long, soon falling away; *limb* 2,1 mm broad, ovate, spreading, abaxial surface puberulous, apex sub-emarginate with a few cilia; *claw* 1,4 mm broad, narrowing to 0,25 mm at the base, strongly transversely bearded with ciliate margins above. *Staminodes* five, 0,15 mm long, vestigial, a minute blunt point on the outer rim of the disc. *Filaments* five, becoming 1,6 mm long, glabrous, acicular. *Anthers* five, before anthesis 1,2 mm long, 1 mm broad, pale yellow, with a minute globose apical gland. *Pollen* 41 μ long, 30 μ broad, ellipsoid. *Disc* green, fleshy, exudes nectar, fairly level on top, closes somewhat over the ovary. *Stigma* 0,7 mm diam., capitate, depressed globose, green. *Style* becoming 1,5 mm long, erect, glabrous, persisting. *Ovary* 5-carpellate, 0,7 mm long, 1,0 mm diam., apices of lobes globose and densely pubescent. *Fruit* 5-carpellate, 9 mm long, 6 mm diam., scabro-tomentose, sessile, closely imbricated at the base by the persistent calyx lobes which have a white waxy exudate on the inside; *horns* 2,5 mm long, sub-erect, obtuse, dark green or reddened. *Seed* 5,5–6,6 mm long, 2–2,5 mm broad, black, shining with a black and white aril.

SPECIMENS EXAMINED

CAPE—3323 (Willowmore): Baviaanskloof Forest Reserve at Studtis, on forestry road at end of first plateau (-DB), 915 m (3 000 ft.) alt., 12/10/1976, Williams 2224 (NBG, AD, B, BOL, K, L, M, MO, NSW, PRE, S, STE); Kouga Mtns., lower foothills, 3 500 ft., 20/9/1953, Taylor 880 (NBG).
—3324 (Steytlerville): Forest Reserve, The Fountains, Humansdorp Div. (-CB), -/11/1933, Laughton s.n. (BOL-FOURC.).

DISTRIBUTION AND BIOLOGY

This vigorous species appears to occur in both the Kouga and Baviaanskloof

mountains on north-facing slopes where it is, according to the Forester, quite common. When the type collection was made in October it was obvious that the flowering season was nearly over and that fruits were ripening plentifully. The plants were found scattered about three metres apart in arid fynbos, growing in extremely stony ground on a gentle slope. They could be detected by a faint smell of fresh 'red bait' (ascidian). The presence of this smell together with nectar in the flowers would indicate that this plant is insect pollinated. The seeds when ripe are ejected by the usual catapult mechanism. Regeneration must take place only from seed as no coppicing was noticed such as may be observed in those plants that regenerate from a persistent rootstock after fires. The leaves when crushed have a smell of cedar and resin.

DISCUSSION

The transversely bearded petal places this plant in the genus *Euchaetis*. Other factors which reinforce this and at the same time exclude it from other genera of the *Diosmeae* are: (1) *flowers* 1-4 nate, terminal; (2) *staminodes* vestigial; (3) *anther* with a minute apical gland; (4) *disc* well developed, closes slightly over the ovary; (5) *stigma* capitate; (6) *style* and *filaments* short and glabrous; (7) *ovary* 5-carpellate.

Euchaetis vallis-simiae is recognised as distinct because of having prominently-nerved, elliptic leaves which, with the bracts, bracteoles and calyx lobes, are conspicuously gibbous behind the apex and scabro-tomentose on both sides. It also has an erect style bearing an unusually large capitate stigma.

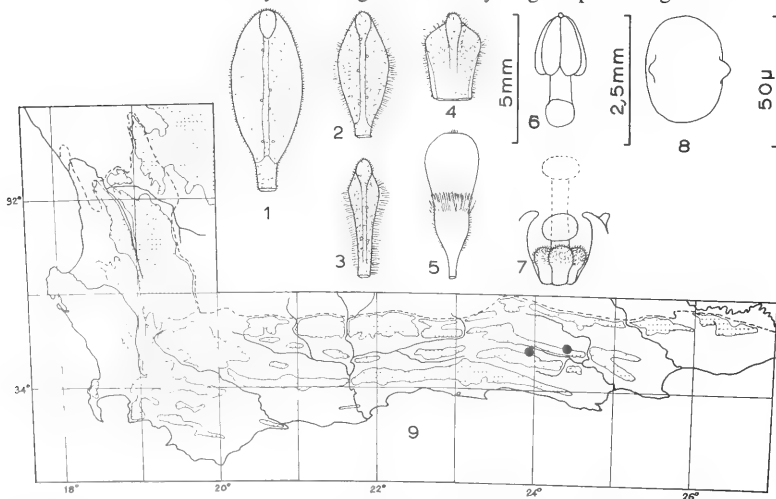


FIG. 5

Euchaetis vallis-simiae: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium and disc. 8, pollen. 9, distribution.



FIG. 6

Euchaetis vallis-simiae: Flower with transversely bearded petals.

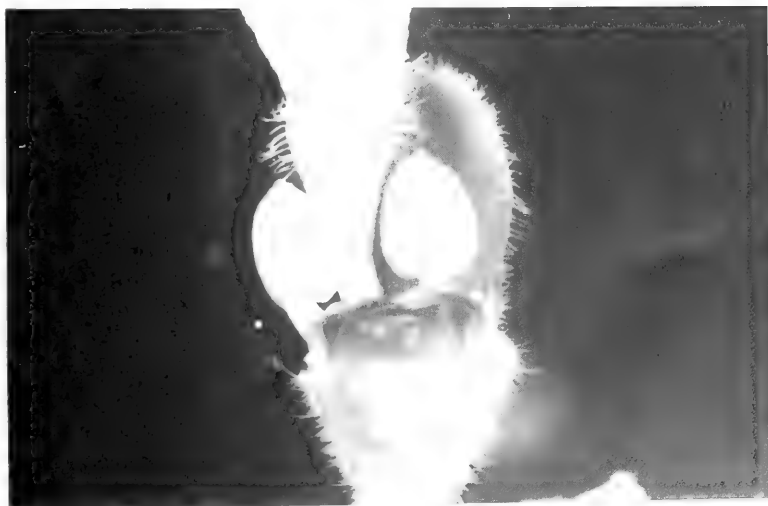


FIG. 7

Euchaetis vallis-simiae: Flower with part removed showing the pubescent ovary, stigma, anthers and disc with nectar.

Acmadenia argillophila Williams, sp. nov. propria propter ramulos 90 ° dichotomos, folia parviora crassa sessilia patentia, flores 10 mm diam. lilacinos, petala orbicularia breve unguiculata patentia, fructum globosum sine cornibus.

Frutex 0,20–0,50 m altus, rigidus, ad basim monocaulis. *Rami* brevi, flexi; cortex asper, cinereus. *Ramuli* brevi, sparsim puberuli, saepe 90 ° dichotomi, expositi. *Folia* 2–3,4 mm longa, 1,4–1,9 mm lata, ovata vel oblonga, obtusa, crassa, glabra, sessilia, patentia, pleurimque opposita, glanduloso-punctata, marginibus crassis. *Inflorescentia* terminalia, 1–4 nata, pleurumque bini; *flos* 1 cm diam., sessilis, lilacinus; alabastrum globosum; calyx glaber. *Bractea* 1 mm longa, 0,9 mm lata, ovata, obtusa, glabra, glanduloso-punctata, sparsim ciliolata, marginibus anguste hyalinis. *Bracteolae* duae, 0,7 mm longae, 0,7 mm latae, sub-ovatae, obtusae, glabrae, glanduloso-punctatae, marginibus ciliolatis, anguste hyalinis. *Sepala* quinque, 1,6 mm longa, 1,6 mm lata, ovata, obtusa, glabra, glanduloso-punctata, rubescentia, apex parum incrassatus, marginibus hyalinis ciliolatis. *Petala* quinque, 4,8–5,2 mm longa, 3,3–3,9 mm lata, breve unguiculata, glabra, lilacina, sparsim glanduloso-punctata. *Staminodia* quinque, 0,5 mm longa, 0,2 mm diam., conica, obtusa. *Filamenta* quinque, post anthesin 2,1 mm longa, acicularia, glabra, rubescentia, incurvo-erecta. *Antherae* quinque, ante anthesin 1,2 mm longae, 1,1 mm latae, vinosae; glandula glutinosa coronata. *Pollen* 44 µ longum, 24 µ latum, oblongum. *Discus* sinuatus, atroviridus, crassus, nectarifer, ovarium aequans. *Stigma* 0,4 mm diam, capitatum, viridum, indistincte 5-lobatum. *Stylus* 0,9 mm longus, glaber, parum flexus. *Ovarium* 5-carpellatum, 0,9 mm longum, 1,1 mm diam., glabrum, apicibus globosis. *Fructus* 5-carpellatus, 13 mm diam., globosus, rubescens vel tri-coloratus, glaber, multi-glanduloso-punctatus, apicibus emarginatis, sine cornibus. *Semen* 5,5 mm longum, 2,5 mm latum, piceum, nitens.

Type: CAPE—3320 (Montagu): Boesmansgat Quarry, 9 km E. of Jan de Boers, Worcester/Laingsburg Division (-AC), 1 006 m (3 300 ft.) alt., 3/8/1977, Williams 2318 (NBG, holotype; BOL, K, MO, PRE, isotypes).

Acmadenia argillophila was apparently collected for the first time in 1965 by Acocks 12 miles due east of Touws River. He informed Mr Hugh Taylor that it was quite probable that he only saw one plant. A recent search failed to rediscover it in this area. However in 1971 it was discovered by both Miss Elsie Esterhuysen and Miss Mary Thompson growing near a small quarry alongside the National Road between Jan de Boers and Constable. Since when the quarry, known as Boesmansgat, has been vastly extended and only five plants remain here. Despite extensive searches no further populations have been found.

Shrubs 0,20–0,50 m tall, rigid, branching from a single stem at ground level. *Branches* short, bent; bark rough, ashy-brown. *Branchlets* short, thinly and minutely puberulous, not hidden by the leaves, often forking at 90 °. *Leaves* 2–3,4 mm long, 1,4–1,9 mm broad, ovate or oblong, obtuse, thick, glabrous, not

shining, sessile, spreading, usually opposite, dorsally gland-dotted; margins thick. *Inflorescence* terminal, 1–4 nate, normally in opposite pairs; *flowers* 10 mm diam., sessile, lilac; *bud* globose; *calyx* glabrous. *Bract* 1 mm long, 0.9 mm broad, ovate, obtuse, glabrous, gland-dotted; margins sparsely ciliate, narrowly translucent. *Bracteoles* two, 0.7 mm long, 0.7 mm broad, sub-ovate, obtuse, glabrous, gland-dotted; margins ciliate, narrowly translucent on all sides. *Calyx lobes* five, 1.6 mm broad, 1.6 mm long, ovate, obtuse, glabrous, gland-dotted, somewhat reddened; apex slightly thickened; margins ciliate, translucent. *Petals* five, 4.8–5.2 mm long, 3.3–3.9 mm broad, glabrous, lilac, with a few gland dots dorsally near the midrib; *limb* orbicular, spreading, margins very sparsely setulose; *claw* about 0.8 mm long, 0.7 mm broad. *Staminodes* five, 0.5 mm long, 0.2 mm diam., conic-obtuse, pale-translucent, arising on the outer side of the disc adjacent to the petals. *Filaments* five, becoming 2.1 mm long, acicular, glabrous, reddened below, apex purplish, incurved erect. *Anthers* five, before anthesis 1.2 mm long including the apical gland, 1.1 mm broad, wine-coloured; apical gland leaning inwards, becoming sticky-tipped before anthesis; thecae rather distant. *Pollen* 44 μ long, 24 μ broad, oblong, slightly waisted. *Disc* sinuate, dark green, fleshy, exudes nectar, never exceeds the ovary. *Stigma* 0.4 mm diam., capitate, green, indistinctly 5-lobed. *Style* becoming 0.9 mm long, glabrous, somewhat bent, sometimes persisting. *Ovary* 5-carpellate, 0.9 mm long, 1.1 mm diam., glabrous, apices globose. *Fruit* 5-carpellate, 13 mm diam., globose, reddened or tri-coloured, hornless, glabrous, many gland-dotted, apices emarginate. *Seed* 5.5 mm long, 2.5 mm broad, black, shining.

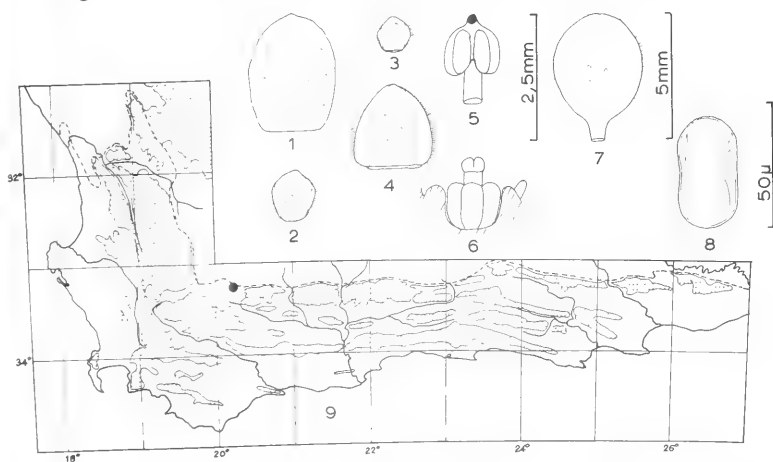


FIG. 8

Acmadenia argillophila: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, anther. 6, gynoecium and disc. 7, petal. 8, pollen. 9, distribution.

SPECIMENS EXAMINED

CAPE—3320 (Montagu): 12 miles as the crow flies E. of Touws River, Laingsburg Division (-AC), 3 400 ft., 13/6/1965, *Acocks* 23637 (PRE); about 21 miles N. of Touws River and a few miles S. of Constable, in rhenosterbos veld, in clay soil near a small quarry, Laingsburg Division, 14/9/1971, *Esterhuysen* 32637 (BOL); valley W. of Konstabel, rhenosterveld, rare, straggly bush, 950 m, 14/9/1971, *Thompson* 1230 (STE); Boesmansgat Quarry, 9 km E. of Jan de Boers, Worcester/Laingsburg Division, 1 006 m (3 300 ft.) alt., 3/8/1977, *Williams* 2318 (NBG, BOL, K, MO, PRE).

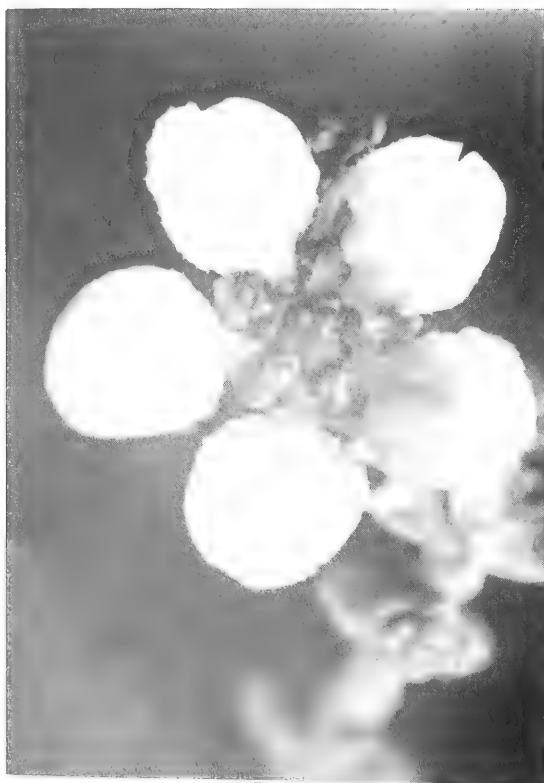


FIG. 9

Acmadenia argillophila: Flower showing clawed petals and disc with nectar and staminodes.

DISCUSSION

This plant is placed in the genus *Acmadenia* because of having flowers terminal, petals clawed, staminodes present, anther with an apical gland, disc obvallate, stigma capitate, style and filaments short and glabrous, ovary 5-carpellate.

A. argillophila with its branchlets forked at 90°, small thick sessile leaves, lilac flowers 10 mm diam., orbicular petals short-clawed and spreading and with its 5-carpellate globose hornless fruit, is a distinct species. It differs from *A. teretifolia* with terete leaves; from *A. tetracarpellata* with a 4-chambered ovary; from *A. patentifolia* with white flowers and horned fruits; from *A. fruticosa* with petiolate leaves and petals incurved at the throat. It is undoubtedly closest to *A. matroosbergensis*, a rather variable species with similar hornless fruits which has: branchlets densely puberulous; leaves which may be much larger, erect and sparsely ciliolate; buds more acute; petals narrowing evenly to the base with many more gland dots; disc exceeding the ovary closing slightly over it; and staminodes 0,5 mm long, reddened with a minute pointed gland at the apex.

Acmadenia rupicola Williams, sp. nov. propria propter folia in ramulis adultis alterna, antheram glande relative magna conica coronatam post anthesin ad apicem glutinescens.

Frutex 0,25 m altus, ad 0,50 m diam., ad basim monocaulis. *Rami* breves, tenices, patuli, asperi. *Ramuli* breves, erecti, puberuli, tecti. *Folia* (petiolis 1,6 mm longis inclusis) 7,4–8,7 mm longa, 2–2,3 mm lata, oblonga, alterna (vel interdum in ramuli ad basim ad 13 mm longa, 2,4 mm lata, lanceolata, opposita), obtusa, erecta, imbricata, puberula, glanduloso-punctata, costata, marginibus opacis. *Inflorescentia* c. 10 mm diam., solitaria, terminalis, sub-rosea, involucrata. *Bracteae* duae, (petiolis 2,5 mm longis inclusis) 8 mm longae, 1,6–1,7 mm latae, lanceolatae, folia similia. *Bracteolae* duae, 7 mm longae, 1,6 mm latae, ad basim 2 mm petiolatae, ad apex lanceolatae, ad basim oblongae; marginibus ciliolatis, anguste hyalinis, cetera folia similia. *Sepala* quinque, 6–7 mm longa, 1,6–1,8 mm lata, oblonga, sub-acuta, puberula, bifariam glanduloso-punctata, marginibus ad basim ciliolatis, anguste hyalinis. *Petala* quinque, 7–8,3 mm longa, 4–4,9 mm lata, orbicularia, apiculata, sub-rosea, glanduloso-punctata; apex parum ciliolata; unguis 2,5 mm longus, glaber vel ad fauce pubescens, ciliatus, costa incrassata. *Staminodia* quinque, 1 mm long, acicularia. *Fila* quinque, post anthesin 1,6 mm longa, glabra, pallida. *Antherae* quinque, ante anthesin 1,3 mm longae, 0,8 mm latae, glande 0,9 mm longa conica coronatae post anthesin ad apicem glutinescens. *Pollen* 41 μ longum, 34 μ latum, sub-sphaericum. *Discus* obvallatus, ovarium excedens, viridus, nectarifer. *Stigma* 0,6 mm diam., globosum, viridum, capitatum. *Stylus* 1 mm longus, erectus, glaber. *Ovarium* 5-carpellatum, 0,7 mm longum, 0,8 mm diam., apicibus lateralibus sparsim pubescentibus, immerso-glandulosis. *Fructus* 5-carpellatus, 4,9 mm longus, 4 mm diam., involucrat:

carpella puberula, glanduloso-punctata, cornibus \pm 0,7 mm longis, immerso-glandulosis. *Semen* 3,5 mm longum, 1,5 mm latum, piceum, nitens, paulo nephroideum.

Type: CAPE—3322 (Oudtshoorn): Robinson Pass, south side, Mossel Bay Division (-CC), 850 m (2 800 ft.) alt., 6/12/1977, *Williams 2431* (NBG, holotype).

As far as can be seen, the only time that this plant had been collected was in December 1951 by Miss Elsie Esterhuysen. Fortunately Mr William Bond of Saasveld re-discovered it in December 1977 thus enabling the preparation of this description.

Shrubs 0,25 m tall, spreading up to 0,50 m diam., single-stemmed at base. *Branches* tough, tending to spread; bark rough with leaf scars; annual increments very small. *Branchlets* short, erect, puberulous, hidden by the leaves. *Leaves* (including the petiole 1,6 mm long) 7,4–8,7 mm long, 2–2,3 mm broad, oblong, alternate, 5-ranked, (or on some lower shoots up to 13 mm long, 2,4 mm broad, lanceolate, opposite, decussate), obtuse, erect, imbricate, puberulous, inconspicuously gland-dotted, towards apex triangular in section; midrib prominent; margins opaque. *Inflorescence* about 10 mm diam., solitary, terminal, pale pink, involucre. *Bracts* two (including the petiole 2,5 mm long), 8 mm long, 1,6–1,7 mm broad, lanceolate, otherwise leaf-like. *Bracteoles* two, 7 mm long, 1,6 mm broad, the lower 2 mm recognisable as a petiole, lanceolate above, oblong below with margins ciliate, narrowly translucent; apex slightly reddened, otherwise leaf-like. *Calyx lobes* five, 6–7 mm long, 1,6–1,8 mm broad, in the same flower, oblong, sub-acute puberulous, gland dots in 2 rows, reddened above; margins below ciliate, narrowly translucent; adaxially puberulous below. *Petals* five, 7–8,3 mm long, 4–4,9 mm broad, orbicular, apiculate, minutely ciliate at the apex, gland-dotted, pink, with a short claw about 2,5 mm long, narrowing below, glabrous or pubescent above, margins ciliate, midrib thickened. *Staminodes* five, 1 mm long, acicular, translucent above. *Filaments* five, becoming 1,6 mm long, stout, glabrous, pale. *Anthers* five, 2,2 mm long including a stout, conical, apical gland 0,9 mm long, 0,8 mm broad, becoming sticky at the tip after anthesis. *Pollen* 41 μ long, 34 μ broad, almost spherical. *Disc* obvallate, at first exceeds the ovary equalling the stigma, quite narrow and level above, green, exudes nectar. *Stigma* 0,6 mm diam., globose, green, capitate. *Style* becoming 1 mm long, erect, glabrous. *Ovary* 5-carpellate, 0,7 mm long, 0,8 mm diam., apices sparsely pubescent to either side of an immersed gland, otherwise glabrous. *Fruit* 5-carpellate, 4,9 mm long, 4 mm diam., involucre; *carpels* puberulous, gland-dotted; *horns* c. 0,7 mm long, apical gland large, facing outward. *Seed* 3,5 mm long, 1,5 mm broad, black, shining, somewhat kidney-shaped.

SPECIMENS EXAMINED

CAPE—3322 (Oudtshoorn): Robinson Pass, summit, on rock above road, S.

aspect, Mossel Bay Division (-CC), 2 500 ft., 5/12/1951, *Esterhuysen 19410* (BOL); Robinson Pass, south side, Mossel Bay Division, 850 m (2 800 ft.) alt., 6/12/1977, *Williams 2431* (NBG), 6/6/1978, *Williams 2522* (NBG).

DISTRIBUTION AND BIOLOGY

So far *Acmadenia rupicola* has only been found in one locality, just above the southern summit of the Robinson Pass where there is a rather isolated outcrop of Table Mountain Sandstone forming the spine of a west-facing rocky ridge. Only about nineteen plants were found growing in this area, so it would appear to be a very rare species. The height above sea level is about 850 m (2 800 ft.) and the plants grow in open rocky places that have managed to escape fires and the attentions of the Forestry Department, for many years. Some of them are obviously very old, their age being estimated as well over 20 years. Although this area receives a good annual rainfall yet the plants are not luxuriant. They appear to be struggling to get any nutriment from their roots in the crevices of the rock. Other perhaps more suitable crevices in the rock are mainly colonised by plants of *Erica viridiflora* Andrews. Very few buds, not many flowers and quite a few fruits were seen in December. In June no fruits were seen but two plants were found to be in bloom. The flowers with their fairly large petals and nectariferous disc are most probably insect pollinated and as the plants are single-stemmed at base, it would appear that regeneration can only take place from seed which is dispersed when ripe by the usual catapult mechanism. The leaves when crushed have almost no smell or perhaps they smell faintly of pine tree or resin.

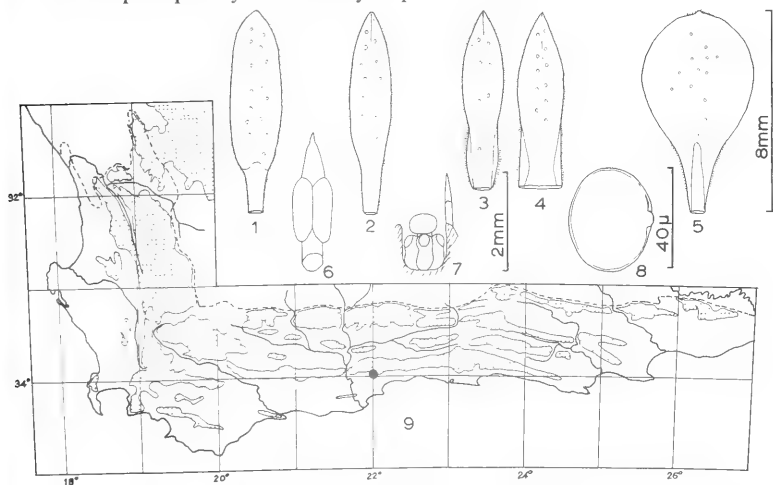


FIG. 10

Acmadenia rupicola: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoeceium and disc. 8, pollen. 9, distribution.

DISCUSSION

The presence in the flower of anthers bearing a pointed apical gland and of staminodes 1 mm long, places this plant in the genus *Acmadenia*. Other characters which support this and exclude it from other genera of the *Diosmeae* are: (1) flowers terminal, solitary; (2) petals clawed; (3) disc obvallate; exceeds the ovary; (4) stigma capitate; (5) style and filaments short, glabrous; (6) ovary 5-carpellate.

Acmadenia rupicola is a distinct species with alternate leaves, having the anther crowned with a relatively large conical gland which becomes sticky at the tip after anthesis. Only three other members of the genus, *A. niveni* Sond., *A. sheilae* Williams and *A. tetragona* (Linn. f.) B. & W., possess anthers bearing a similar conical gland, however they all have leaves opposite, never alternate.

Acmadenia tenax Williams, sp. nov. propria propter fruticem tenicem scopulophilum glabrum, flores 13 mm diam., petala alba, antheras apicibus globuloso-glandulosis, stylos initio deflexos, fructum glabrum cornibus 3–5 mm longis.

Frutex tenax, ad basim monocaulis, in scopulis crescens. *Rami* effusi, flexisimi. *Ramuli* erectiusculi, graciles, glabri, brevissimi. *Folia* (petiolis 0,8–1 mm longis inclusis) 10–13,5 mm longa, 1,3–1,7 mm lata, lineari-lanceolata, acuta, alterna, erecto-patentia, recurviuscula, creba, glabra, glanduloso-punctata; apex obtuse mucronulata; marginibus irregulariter serrulatis vel denticulatis, anguste cartilagineis. *Inflorescentia* 13 mm diam., solitaria, terminalis, sessilia, alba. *Bractea* 1,6 mm longa, 0,6 mm lata, lanceolata, digito-apiculata, ciliata, 2–3 glanduloso-punctata, intus pubescentia. *Bracteolae* duae, 1,4 mm longae, 0,6 mm latae, ovatae, ciliatae, 1–2 glanduloso-punctatae, subacutae, intus sparsim pubescentes, marginibus late hyalinis. *Sepala* quinque, 3 mm longa, 1,5 mm lata, deltoidea, erecta, intus pubescentia, glanduloso-punctata, marginibus ciliatis, late hyalinis. *Petala* quinque, 7–9 mm longa, 4–4,5 mm lata, alba, glabra; *limbus* recurvus, obovatus, extus glanduloso-punctatus, marginibus sparsim ciliatis; unguis c. 2 mm longus. *Staminodia* quinque, c. 1 mm longa, glandulosa, glabra. *Filamenta* quinque, post anthesin 2,5 mm longa, patentia, glabra, acicularia. *Antherae* quinque, ante anthesin 1,2 mm latae, 0,8 mm longae, flavidae, glandula globosa coronata. *Pollen* 53 μ longum, 27 μ latum ellipticum. *Discus* obvallatus, ovarium excedens, nectarifer. *Stigma* 0,25 mm diam., capitellatum. *Stylus* primus deflexus deinde erectus, 2 mm longus, glaber, persistens. *Ovarium* 5-carpellatum, glabrum, apicibus globosis. *Fructus* 5-carpellatus, 9–11 mm longus, c. 6 mm diam., glaber, minute glanduloso-punctatus, forte nervatus; *cornua* 3–5 mm longa, erectiuscula. *Semen* 4–5 mm longum, 1,75 mm latum, piceum, nitens.

Type: CAPE—3319 (Worcester): uppermost left hand fork of Jan du Toit's Kloof, Hex River Mountains, near Mount Brodie, Worcester Division (-AD/CB), 1 646 m (5 400 ft.) alt., 18/2/1978. *Esterhuysen* 34852 (BOL, holotype; E, K, L, LD, M, MO, NBG, PRE, S, isotypes).

In January, 1949 Miss Elsie Esterhuysen gathered this plant whilst climbing

with a party up the ledges and steep rocky slopes at the head of Jan du Toit's Kloof in the Waaihoek Mountains. Now, almost thirty years later, she most kindly consented to endeavour to rediscover it so that it could be described. This time, instead of climbing up by way of Jan du Toit's Kloof, she thought it might be easier to ascend via the path to the University ski hut in the Waaihoek Mountains and then to traverse across to Perry Refuge which is relatively close to Mount Brodie. She was accompanied by Mr Reiger van der Vlugt and Mr David Morrison and the expedition, which took three days, was most successful. The information and material collected has been used as a basis for this description and also for a study of its chemical components by Dr Peter Waterman of the University of Strathclyde in Glasgow.

Shrubs about 0,3 m tall, sometimes creeping about 2 m along ledges, growing from a single stem at base, firmly rooted in crevices in the cliff face. *Branches* tough, sprawling or hanging down, bent at all angles, with a dark brown rough bark. *Branchlets* fairly erect, slender, glabrous, very short, somewhat hidden by the leaves. *Leaves* 10–13,5 mm long (including the petiole 0,8–1 mm long), 1,3–1,7 mm broad, linear-lanceolate, acute, alternate, spreading-erect, somewhat recurved, crowded, glabrous; apex with a small blunt mucro; margins irregularly and minutely serrulate or denticulate, narrowly cartilaginous; adaxial surface smooth and flat when fresh; abaxial surface rounded with two rows of gland dots to either side of the midrib. *Inflorescence* 13 mm diam., solitary, terminal, sessile, white. *Bract* 1,6 mm long, 0,6 mm broad, lanceolate-apiculate with a finger-like tip, ciliate, glabrous with 2–3 gland dots on the midrib, adaxially pubescent. *Bracteoles* two, 1,4 mm long, 0,6 mm broad, ovate, sub-acute with a blunt apex, ciliate with broad translucent margins, glabrous with 1–2 gland dots towards the midrib, adaxially very sparsely pubescent. *Calyx lobes* five, 3 mm long, 1,5 mm broad, deltoid with a blunt point, glabrous, gland-dotted to either side of the midrib, erect; adaxially pubescent; margins ciliate, broadly translucent. *Petals* five, 7–9 mm long, 4–4,5 mm broad, white, glabrous, clawed; *limb* recurved, obovate, margins with one or two minute cilia, abaxially gland-dotted; *claw* about 2 mm long narrowing to the base. *Staminodes* five, about 1 mm long, pale, glabrous, apex with a somewhat pointed gland. *Filaments* five, becoming 2,5 mm long after anthesis, spreading, glabrous, acicular, pale. *Anthers* five, before anthesis 1,2 mm long, 0,8 mm broad, yellow with a sessile, globose apical gland. *Pollen* 53 μ long, 27 μ broad, elliptic. *Disc* obovate, rather narrow, more or less level on top, greenish, exceeds the ovary, exudes nectar. *Stigma* 0,25 mm diam., capitellate, green. *Style* deflexed at first becoming 2 mm long, erect, glabrous, persisting. *Ovary* 5-carpellate, glabrous, apices globose. *Fruit* (from Esterhuysen 15080) 5-carpellate, 9–11 mm long, about 6 mm diam.; *carpels* glabrous, strongly veined when dry, minutely gland-dotted; *horns* 3–5 mm long, fairly erect, each with an immersed apical gland. *Seed* (from Esterhuysen 15080) 4–5 mm long, 1,75 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3319 (Worcester): uppermost left hand fork of Jan du Toit's Kloof, Hex River Mountains, near Mount Brodie, Worcester Division (-AD/CB), 1 646 m (5 400 ft.) alt., 18/2/1978, *Esterhuysen 34852* (BOL, E, K, L. LD, M, MO, NBG, PRE, S); ledges and steep rocky slopes at head of Jan du Toit's Kloof, Waaihoek Mountains, Worcester Division, 4 500 ft. alt., 22/1/1949, *Esterhuysen 15080* (BOL).

DISTRIBUTION AND BIOLOGY

So far *Acmadenia tenax* has been found only in one locality at the head of Jan du Toit's Kloof in the Hex River Mountains. The plants are very firmly rooted in horizontal crevices in almost vertical cliffs of Table Mountain Sandstone. Mostly facing south, they receive very little sunlight. The plants are spaced about three metres apart and there are no plants amongst the vegetation at the base of the cliff. The plants appear to be inaccessible to fires and are quite old. One branch about 1.25 m long and 19 mm diameter showed about 68 rings and at least 43 annual increments in length. It was sprawling along a ledge. Plants were seen with stems up to about 40 mm diameter which could therefore have been about 190 years old. The conspicuous petals, the at first deflexed style and the presence of nectar indicate that this plant is insect pollinated. Seeds when ripe are ejected by the usual catapult mechanism and, when one considers the locality, just how regeneration can take place remains a mystery.

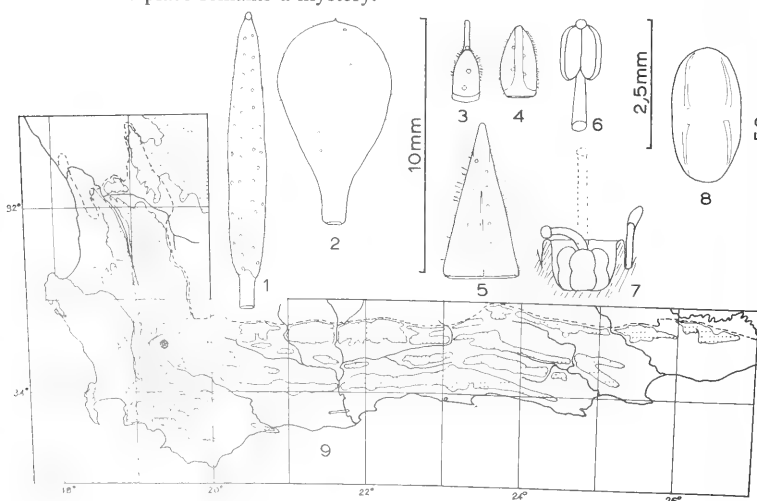


FIG. 11

Acmadenia tenax: 1, leaf. 2, petal. 3, bract. 4, bracteole. 5, calyx lobe. 6, anther. 7, gynoecium and disc. 8, pollen. 9, distribution.

DISCUSSION

In placing this plant in the genus *Acmadenia* one takes account of the following characters some or all of which exclude it from all other genera of the *Diosmeae*: (1) *flowers* solitary, terminal; (2) *petals* clawed; (3) *staminodes* 1 mm long tipped with a gland; (4) *filaments* and *style* glabrous and short equalling the claws; (5) *anthers* with a small sessile apical gland; (6) *disc* obvallate, exceeds the ovary but does not close over it; (7) *stigma* capitellate; (8) *ovary* 5-carpellate.

Acmadenia tenax is recognised as distinct because of being a tough, glabrous plant growing on cliffs, with large white flowers, having anthers with a small sessile globose apical gland and a style at first deflexed, the fruit glabrous with horns 3–5 mm long. Only three other species of *Acmadenia* have the style deflexed at first, *A. teretifolia*, *A. tetracarpellata* and *A. wittebergensis*, but all of these have fruits with truncated or very short horns. Of all the species of *Acmadenia* with white flowers, *A. tenax* has the largest petals.

Diosma arenicola Williams, sp. nov. propria propter folia lanceolata pungentia crispo-ciliata costis sparsim pubescentibus, bracteolas 4 mm longas lineares crispo-ciliatas costis pubescentibus.

Frutex ad 1,5 m, ad basim monocaulis. *Rami* erectiusculi, varie flexi, glabrescenti. *Ramuli* numerosi erecti, brevi, graciliusculi, dense pubescenti. *Folia* variantes, ad 17 mm longa, 3,3 mm lata, opposita, in juvenibus; 5,5–10,5 mm longa, 2,4 mm lata, alterna, in adultis, lanceolata, pungentia, breve petiolata, erecto-patentia, glanduloso-punctata, costis sparsim pubescentibus, marginibus hyalinis crispo-ciliatis. *Inflorescentia* 1–4 nata, crebra, terminalis; *flos* 8 mm diam., patens, album. *Bractea* 5–6 mm longa, 1–2 mm lata, linearis vel lanceolata, rubro-pungentia, glabra vel ad costam sparsim pubescentia, eglandulosa, marginibus hyalinis crispo-ciliatis. *Bracteolae* duae, 4–4,3 mm longae, 0,6 mm latae, lineares, crispo-ciliatae, costis pubescentibus. *Sepala* quinque, 3,5–4 mm longa, 1,5–1,7 mm lata, deltoidea, pungentia, costis ad basim sparsim pubescentibus, marginibus late hyalinis crispo-ciliatis. *Petala* quinque, 3–3,6 mm longa, 1,8–2,3 mm lata, elliptica, recurvo-apiculata, glabra, alba, sparsim ciliata, sessilia. *Staminodia* carentia. *Filamenta* quinque, post anthesin 2,2 mm longa, acicularia, glabra, pallida, patentia. *Antherae* ante anthesin 1,4–1,6 mm longae, 0,8 mm latae, aurantiacae vel vinosae, apicibus semi-immerso-glandulosi. *Pollen* 66 μ longum, 28 μ latum, oblongum. *Discus* 2,5 mm diam., patens, 5-sinuato-crenulatus, crassus, pallenti-viridus, nectarifer, ovarium longe excedens. *Stigma* 0,25 mm diam., capitellatum, pallenti-viride. *Stylus* 1,3 mm longus, glaber, per anthesin deflexus, persistens. *Ovarium* 5-carpellatum, 0,8 mm longum, 0,7 mm diam., glabrum, apicibus globosis. *Fructus* 5-carpellatus, 9 mm longus, 7 mm diam., glaber, oleosus, multi-glanduloso-punctatus; *cornibus* c. 2 mm longis, erectis. *Semen* (cum arilo) 5,5 mm longum, 2,6 mm latum, piceum, nitens.

Type: CAPE—3419 (Caledon): Soetanytsberg above the farm Hangnes, Bredasdorp

Division (-DB), 180 m (600 ft.) alt., 25/5/1978, *Williams* 2507 (NBG, holotype; BOL, K, MO, PRE, S, isotypes).

Diosma arenicola appears to have been first collected by H. Bolus in July 1895 "in hills near Bredasdorp". Towards the end of the next year he collected it again "in hills (at) Rietfontein Poort near Elim"; a place in the Soetansysberg very near to the type locality. Schlechter's collection no. 7713 rather vaguely labelled "Elim 300 ft." undoubtedly comes from the same area. Schlechter distributed duplicates of his 7713 to many herbaria.

Shrubs to 1,5 m tall, arising from a single stem at base. *Branches* fairly erect, variously bent, glabrescent; *bark* brown, somewhat roughened with leaf scars. *Branchlets* numerous, erect, short, fairly slender, densely pubescent, pale green, partly visible between the leaves. *Leaves* variable in size, in young plants up to 17 mm long, 3,3 mm broad, opposite; in mature plants 5,5–10,5 mm long, 2,4 mm broad, alternate, lanceolate, pungent, short-petiolate, spreading-erect; midrib sparsely pubescent, gland-dotted to either side; margins crisped ciliate, translucent. *Inflorescence* 1–4 nate, terminal, crowded; *flower* 8 mm diam., white, spreading. *Bract* 5–6 mm long, 1–2 mm broad, linear or lanceolate, red pointed, glabrous or sparsely pubescent along the midrib, without gland dots, margins shaggy ciliate, translucent. *Bracteoles* two, 4–4,3 mm long, 0,6 mm broad, linear, midrib pubescent, margins shaggy ciliate. *Calyx lobes* five, 3,5–4 mm long, 1,5–1,7 mm broad, deltoid, pungent; midrib sparsely pubescent below; margins broadly translucent, crisped ciliate. *Petals* five, 3–3,6 mm long, 1,8–2,3 mm broad, elliptic, recurved-apiculate, glabrous, sparsely ciliate, sessile. *Staminodes* absent. *Filaments* five, becoming 2,2 mm long, acicular, glabrous, pale, spreading. *Anthers* before anthesis 1,4–1,6 mm long, 0,8 mm broad, orange or purplish; apical gland globose, semi-immersed. *Pollen* 66 μ long, 28 μ broad, oblong. *Disc* 2,5 mm diam., opens widely, 5-sinuate-crenulate, thick, pale green, exudes nectar, exceeds the ovary by a long way. *Stigma* 0,25 mm diam., capitellate, pale green. *Style* becoming 1,3 mm long, deflexed at anthesis, persisting, glabrous. *Ovary* 5-carpellate, 0,8 mm long, 0,7 mm diam., glabrous, apices globose. *Fruit* 5-carpellate, 9 mm long, 7 mm diam., glabrous, oily, multi-gland-dotted, veined when dry; *horns* about 2 mm long, erect, red tipped with an immersed gland. *Seed* (including the aril) 5,5 mm long, 2,6 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3419 (Caledon): Groothagelkraal, limestone hills, Bredasdorp Division (-DA), 400 ft., 24/4/1978, *Williams* 2482 (NBG); Groothagelkraal River area, N.E. of farmstead, limestone slopes, Bredasdorp Division, 300 ft., 28/4/1975, *Oliver* 5889 (STE); Hagelkraal, limestone hills, Bredasdorp Division, 28/12/1946, *Compton* 19037 (BOL, NBG); Hagelkraal River, limestone hills, Bredasdorp Division, 27/12/1946, *Leighton* 2542 (PRE, BOL); Limestone hills

2–3 miles inland from Pearly Beach, Bredasdorp Division, 7/10/1972, *Esterhuysen* 32978 (BOL); Soetanyberg above the farm Hangnes, Bredasdorp Division (-DB), 180 m, 25/5/1978, *Williams* 2507 (NBG, BOL, K, MO, PRE, S); Elim, Bredasdorp Division, 300 ft., 24/4/1896, *Schlechter* 7713 (BM, BOL, G, GRA, K, P, PRE, S); In collibus Rietfontein Poort prope Elim, Bredasdorp Division, 200 ft., 10/12/1896, *H. Bolus* 8530 (BOL, K, NBG); Uintjieskuil, limestone hills, Bredasdorp Division, 200 ft., 16/1/1968, *Van Breda and Admiraal* 2330 (PRE); Brandfontein, about $\frac{3}{8}$ mile from the sea, Bredasdorp Division (-DD), 70 ft., 11/1/1972, *Williams* 1620 (NBG); Brandfontein, S. side of ridge on top of hills, Bredasdorp Division, 14/10/1951, *Esterhuysen* 19059 (BOL, LD, PRE); Side of Wolwekloof on S. slope of Soetanyberg, Bredasdorp Division, 100 ft., 16/11/1927, *Smith* 5030 (K, PRE); In Wolwekloof, Bredasdorp Division, 75 ft., 16/10/1927, *Smith* 5015 (PRE).

—3420 (Bredasdorp): In collibus prope Bredasdorp (-CA), 300 ft., -/7/1895, *H. Bolus* 8475 (BOL); 6 miles S.W. of Bredasdorp, fynbos on limestone slope, 200 ft., 25/9/1949, *Acocks* 15467 (K, PRE); Cape Agulhas, in sand at base of hills, Bredasdorp Division (-CC), 18/9/1962, *Esterhuysen* 29694 (BOL, PRE, S); Struisbaai, Bredasdorp Division, 50 ft., 21/6/1972, *Williams* 1657 (NBG, PRE); Northumberland Point, Bredasdorp Division, 20 ft., 25/8/1962, *Acocks* 22629 (K, PRE).

DISTRIBUTION AND BIOLOGY

Diosma arenicola is found in sandy soil closely associated with limestone deposits of the Bredasdorp geological series. Its distribution extends from near Bredasdorp in the east to Hagelkraal in the west, all within a few kilometres of the sea coast. Further towards the east its particular habitat is taken over by *Diosma sabulosa* which extends as far as Albertinia. From Hagelkraal towards the west *Diosma subulata* and *Diosma awilana* occupy a similar habitat. A section through the stem of one plant, 17–22 mm diameter, showed about 11 growth rings. The open white flower with its nectariferous disc and, at first, deflexed style is most probably pollinated by insects. Being single-stemmed at base, and thus unable to coppice after fires, regeneration can only take place from seed which is ejected in the usual way by a catapult mechanism.

Flowers have been found in almost every month of the year. Fruiting has been observed from May to December.

VARIATION

Plants from the eastern end of the distribution range may have the midrib of the leaf, bract, bracteole and calyx lobes glabrous whilst still remaining very plainly crisped ciliate.

DISCUSSION

The white flower with its spreading sessile petals and open sinuate-crenulate

disc, exceeding the ovary by a long way, immediately places this plant in the genus *Diosma*.

Diosma arenicola is a distinct species with leaves lanceolate with a straight sharp point, with margins crisped ciliate and with the midrib often sparsely pubescent; with bracteoles 4 mm long, linear, crisped ciliate and pubescent along the midrib; and with flowers crowded and sessile. It differs from *D. awilana* which has leaves much broader and more recurved at the apex, bracteoles much less hairy and only half as long and fruits with much longer horns. It is closest to *D. subulata* which however is a much more glabrous plant with bracts, bracteoles and calyx lobes short-ciliate not long crisped-ciliate and with flowers in very much reduced racemes not crowded and sessile.

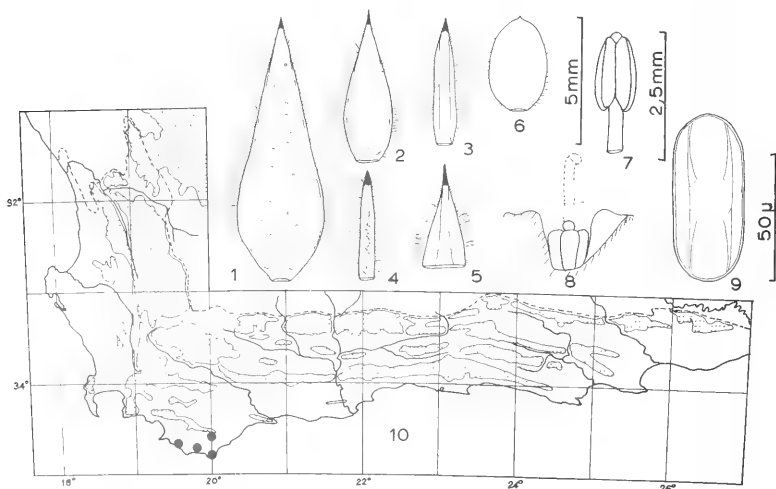


FIG. 12

Diosma arenicola: 1, leaf. 2, outer bract. 3, inner bract. 4, bracteole. 5, calyx lobe. 6, petal. 7, anther. 8, gynoecium and disc. 9, pollen. 10, distribution.

Diosma haelkraalensis Williams, sp. nov. propria propter fruticem decumbentem, ramulos brevissimos, folia recurvopatentia parva, flores parvos albos.

Frutex 0,10–0,30 m altus, decumbens, tegetes c 1 m diam. formantes. *Rami* tenices, decumbentes, flexissimi; cortex aspra. *Ramuli* brevi, erectiusculi, glabri vel minute puberuli, pallidi, eglandulosi. *Folia* 3,8–4,2 mm longa, 1,8–2,2 mm lata, ovato-lanceolata, obtusa vel sub-acuta, mucronulata, glabra, glanduloso-punctata, sessilia, opposita, ternata, patentia vel recurva, marginibus anguste hyalinis, glanduloso-punctatis. serrulatis, ad basim sparsim setulosis. *Inflorescen-*

tia terminalis, solitaria vel bini, 5–5,5 mm diam., alba; *calyx* laevigatus. *Bractea* 1,5 mm longa, 1 mm lata, ovato-lanceolata, obtusa, glabra, marginibus late hyalinis, ciliolatis. *Bracteolae* duae, 1,2 mm longae, 1 mm latae, ovatae, obtusae, glabrae, marginibus minute ciliolatis, anguste hyalinis. *Sepala* quinque, 1,7 mm longa, 1,2 mm lata, deltoidea, glabra, apicibus incrassatis, marginibus ad basim late hyalinis, ciliolatis. *Petala* quinque, 2,2–2,3 mm longa, 1,5 mm lata, ovata, glabra, alba, patentia, sessilia. *Staminodia* quinque, vestigialia. *Filamenta* quinque, post anthesin 1,8 mm longa, glabra. *Antherae* quinque, ante anthesin 1,3 mm longae, 0,8 mm latae, glandula semi-immersa coronata. *Pollen* 50 μ longum, 25 μ latum, ellipticum. *Discus* patens, ovarium excedens, margine carnosus, virido, sinuato-crenulato, nectarifero. *Stigma* 0,25 mm diam., globosum, capitellatum. *Stylus* glaber, ab initio deflexus deinde erectus, 1,5 mm longus. *Ovarium* 5-carpellatum, 0,6 mm longum, 0,7 mm diam., glabrum, apicibus spiculatis. *Fructus* 5-carpellatus, 7–8 mm longus, 5,5 mm diam., glaber, cornibus c. 3 mm longis, sparsim setulosis, obtusis, sub-emarginatis. *Semen* 3,5–4 mm longum, 1,6–2 mm latum, piceum, nitens.

Type: CAPE—3419 (Caledon): 2 km E.N.E. of Groothagelkraal, Bredasdorp Division (-DA), 110–170 m (350–550 ft.) alt., 24/4/1978, Williams 2486 (NBG, holotype; K, MO, PRE, S, isotypes).

As recently as October 1972 Miss Elsie Esterhuysen made a collection of this species. She discovered it growing on limestone hills between one and two miles inland from Pearly Beach to the western end of the Bredasdorp Division. Although several other botanists had previously made collections in this area, it seems to have been overlooked by all of them. More recently in April 1975 it was found in more or less the same area by E. G. H. Oliver.

Shrubs 0,10–0,30 m tall, decumbent, 1 m diam., forming dense mats. *Branches* tough, prostrate, bent at all angles; bark rough. *Branchlets* short, sub-erect, glabrous or minutely puberulous, pale, shining without any gland dots, well-clothed with leaves, but not hidden. *Leaves* 3,8–4,2 mm long, 1,8–2,2 mm broad, ovate-lanceolate, obtuse or sub-acute with a small blunt mucro, glabrous, gland-dotted towards midrib and margins, sessile, opposite, ternate, spreading or reflexed and somewhat recurved; margins narrowly translucent, serrulate-denticulate to setulose towards the base. *Inflorescence* terminal, solitary or twin, 5–5,5 mm diam., white; *calyx* glabrous, shining. *Bract* 1,5 mm long, 1 mm broad, ovate-lanceolate with a blunt point, glabrous, spreading; margins below ciliolate and broadly translucent. *Bracteoles* two, 1,2 mm long, 1 mm broad, ovate, obtuse, glabrous; margins minutely ciliolate, narrowly translucent. *Calyx lobes* five, 1,7 mm long, 1,2 mm broad, deltoid, glabrous; apex thickened, somewhat recurved; margins below ciliolate and broadly translucent. *Petals* five, 2,2–2,3 mm long, 1,5 mm broad, ovate, somewhat thickened at the tip, glabrous, white, sessile, spreading. *Staminodes* five, an immersed vestigial gland at the

summit of the lobe of the disc very close to the base of the petal. *Filaments* five, acicular, glabrous, becoming 1,8 mm long after anthesis. *Anthers* five, before anthesis 1,3 mm long, 0,8 mm broad, dorsally somewhat pink, yellow in front; apical gland globose, semi-immersed. *Disc* stands open, exceeds the ovary by a long way; margin sinuate-crenulate, fleshy, dark green, exudes nectar. *Stigma* 0,25 mm diam., globose, capitellate. *Style* deflexed at first, becoming 1,5 mm long, glabrous. *Ovary* 5-carpellate, 0,6 mm long, 0,7 mm diam., glabrous with the apices roughened with a dense layer of minute conical points (spiculate). *Fruit* (from *Williams* 2503) 5-carpellate, 7–8 mm long overall, 5,5 mm diam., glabrous; *horns* about 3 mm long, sparsely and minutely setulose above; apices obtuse sub-emarginate with an immersed gland. *Seed* 3,5–4 mm long overall, 1,6–2 mm broad, black, shining.

SPECIMENS EXAMINED

CAPE—3419 (Caledon): 2 km E.N.E. of Groothagelkraal, Bredasdorp Division (-DA), 110–170 m (350–550 ft.) alt., 24/4/1978, *Williams* 2486 (NBG, K, MO, PRE, S); Groothagelkraal, N.E. of farmstead, Bredasdorp Division, 300 ft., alt., 28/4/1975, *Oliver* 5890 (STE); Limestone hills 1–2 miles inland from Pearly Beach, Bredasdorp Division, 8/10/1972, *Esterhuysen* 32983 (BOL).

DISTRIBUTION AND BIOLOGY

Diosma haelkraalensis appears to be confined to a small group of limestone hills, not more than 2,5 km long, situated about 2 km to the north east of Groothagelkraal homestead. It grows in crevices upon and amongst limestone rocks of the Bredasdorp geological formation in what must be a very harsh environment. The plants are found at altitudes of between 100 and 200 metres above sea level, pressed down by the prevailing winds and spreading out to form dense mats up to 1 m diameter. A section of the stem of one plant about 22 m diameter showed about 30 growth rings. The small open white flower with its nectariferous disc and, at first, deflexed style is most probably pollinated by insects. Regeneration is from seed which is ejected when ripe by the usual catapult mechanism. The leaves when crushed have a very strong smell, much stronger than those of *Diosma guthriei* which is obviously a very closely related species also associated with the limestone but found about 30 kilometres further to the east.

DISCUSSION

The white flower with its spreading sessile petals and the open disc, exceeding the ovary by a long way with its fleshy, sinuate-crenulate margin immediately places this plant into the genus *Diosma*.

Diosma haelkraalensis with its decumbent habit, very short branchlets, small somewhat recurved leaves and small white flowers is a distinct species. It is one of

a series of four very similar and quite possibly vicarious taxa which are found growing on the limestone more or less along the coast from Walker Bay in the west to about Still Bay in the east. The others are *D. demissa* Williams which differs in having leaves alternate, obtuse with a single row of gland dots along the midrib; *D. guthriei* Glover which differs in having leaves ovate, often opposite, more erect and thicker with margins not translucent; and *D. echinulata* Williams, which differs in having leaves alternate, lanceolate-elliptic, mucronate and sparsely setose on all sides.

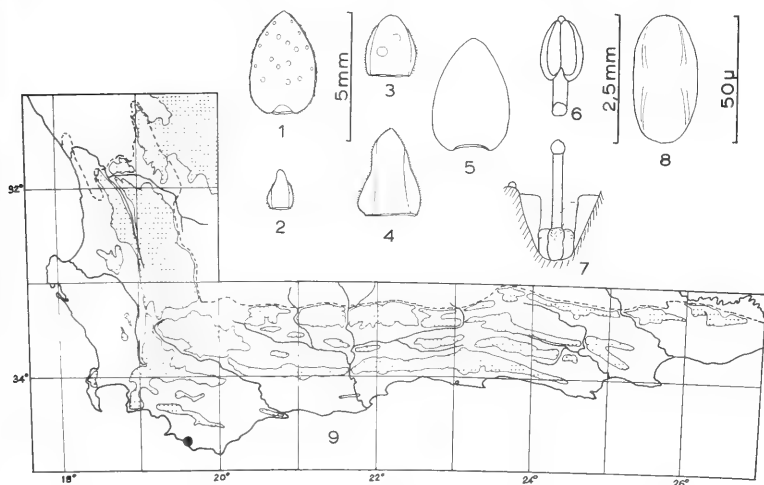


FIG. 13

Diosma haelkraalensis: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoeceium and disc. 8, pollen. 9, distribution.

***Diosma pedicellata* Williams, sp. nov.** propria propter fruticem altum rigidum ramosum ad basin multi-caulem, folia petiolata recti-mucronata anguste costata, flores 7 mm diam. calycibus glabris et lobis obtusis, petala patentia glabra peranguste connexa marginibus irregularibus, fructum supra calycem pedicellascens.

Frutex c. 1 m altus, rigidus, ramosus, ad basin multicaulis. *Rami* erecti, rigidi, furcati, glabri. *Ramuli* erecti, graciles, nunquam numerosi, sub-dichotomi, glabrescenti. *Folia* (petiolis 1 mm longis inclusis) 8–12,5 mm longa, 0,8–1 mm lata, lineari-lanceolata, acuta, recti-mucronata, glabra, glanduloso-punctata, alterna, erecto-patens, marginibus anguste hyalinis, sparsim serrulatis. *Inflorescentia* terminalia, solitaria vel pseudo-bini, reducto-racemosa; *flos* 7 mm diam. *Bractea* 1 mm longa, 0,7 mm lata, late-lanceolata, acuta, mucronulata, glabra, sparsim

glanduloso-punctata, marginibus hyalinis minute ciliolatis. *Bracteolae* duae, 0,8 mm longae, 0,7 mm latae, ovatae, minute apiculatae, sparsim glanduloso-punctatae, marginibus hyalinis minute ciliolatae. *Sepala* quinque, 1,3 mm longa, 1,5 mm lata, late ovata, obtusa, glabra, sparsim glanduloso-punctata, apicibus incrassatis, marginibus hyalinis minute ciliolatis. *Petala* quinque, 2,5 mm longa, 1,8 mm lata, late elliptica, glabra, alba, sessilia, patentia, marginibus irregulariter ciliato-denticulata. *Staminodia* 0. *Filamenta* quinque, post anthesin 1,7 mm longa, acicularia, glabra, patentia. *Antherae* quinque, ante anthesin, 0,9 mm longae, 0,8 mm latae, flavidae, glandula sessilia coronata. *Pollen* 51 μ longum, 29 μ latum, ellipticum. *Discus* 5-lobatus, sinuatus, patens, viridus, succulentus, minute punctulatus, ovarium longe excedens. *Stigma* 5-lobatum, 0,2 mm diam., capitellatum. *Stylus* primus deflexus deinde erectus 1,3 mm longus, glaber. *Ovarium* 5-carpellatum, 0,7 mm diam., glabrum, apicibus globosis. *Fructus* 5-carpellatus, 1,2 mm longus, 0,8 mm diam., glaber, glanduloso-punctatus, ad maturitatem supra calycem pedicellatus. *Semen* c. 7 mm longum, 3 mm latum, piceum, nitens; arilus pro parte maxima piceus.

Type: CAPE—3218 (Clanwilliam): 6 km north of Papkuilsfontein, near Aurora, Piquetberg Division (-CB), 76 m (250 ft.) alt., 11/8/1977, *Williams* 2328 (NBG, holotype; K, MO, PRE, isotypes).

Diosma pedicellata, was apparently first collected by C. P. Thunberg. In 1744, when at the Cape of Good Hope, his route on the way to the Roggeveld must have passed through the sandy plains to the south and west of the Picketberg where this plant is abundant. It is apparent from the specimens in Thunberg's herbarium that he considered it, as well as two other species collected elsewhere, to be conspecific with *Diosma rubra* L. (= *Coleonema rubrum* (L.) Druce). Ecklon and Zeyher, who collected this plant near Tulbagh, misidentified it as 845 *Diosma linearis* Thunb. and again as 846 *Diosma longifolia* Wendl. Drège also collected this plant but failed to cite it in his "Documente". Sonder considered it to be a variety of *Diosma aspalathoides* Lam. with longer leaves. At a first glance, herbarium material of this plant looks rather like *D. hirsuta* and it was only the appearance of the fruits which are pedicellate above the calyx in Drège's specimen in the herbarium at Kew Gardens that drew my attention to it as being unique.

Shrubs about 1 m tall, rigid, much-branched, many-stemmed with a stout rootstock. *Branches* erect, rigid, glabrous, forked; bark reddish-brown becoming ashy-grey with leaf scars slightly raised. *Branchlets* erect, slender, not very numerous, not hidden by the leaves, sub-dichotomous, soon glabrous. *Leaves* (including the petiole 1 mm long) 8–12,5 mm long, 0,8–1 mm broad, linear-lanceolate, acute, glabrous, alternate, erect-spreading; apex mucronate with a straight point; margins narrowly hyaline, sparsely serrulate; abaxial surface rounded with gland dots scattered to either side of the midrib; adaxial surface concave. *Inflorescence* terminal, solitary or pseudo-twin in slender reduced

racemes; flowers 7 mm diam., opening in succession, delapsing if infertile. *Bract* 1–2 mm long, 0.7 mm broad, broadly lanceolate, acute, mucronate, glabrous, sparsely gland-dotted; margins minutely ciliolate. *Bracteoles* two, 0.8 mm long, 0.7 mm broad, ovate, minutely apiculate, sparsely gland-dotted; margins minutely ciliolate, translucent. *Calyx lobes* five, 1.3 mm long, 1.5 mm broad, broadly ovate, obtuse, glabrous, sparsely gland-dotted; apex thickened; margins minutely ciliolate, translucent. *Petals* five, 2.5–3 mm long, 1.8–2.5 mm broad, orbicular, white, glabrous, sessile, spreading, arising high up on the lobe of the disc; margins ciliate-denticulate, irregular. *Staminodes* none. *Filaments* five, becoming 1.7 mm long after anthesis, acicular, spreading, glabrous. *Anthers* five, before anthesis 0.9–1.1 mm long, 0.8 mm broad, yellow, apical gland sessile, inclined inwards. *Pollen* 51 μ long, 29 μ broad, elliptic, many malformed. *Disc* 5-lobed, sinuate, green, fleshy, minutely punctate, spreading, exceeding the ovary by a long way. *Stigma* 0.2–0.4 mm diam., capitellate, green. *Style* becoming 1.3–1.7 mm long, glabrous, deflexed at first. *Ovary* 5-carpellate, 0.7 mm diam., glabrous, lobes obtuse. *Fruit* 5-carpellate, 1.2 mm long overall, 0.8 mm diam., glabrous, pitted with gland dots, becoming \pm 2.5 mm pedicellate above the calyx when mature; *horns* \pm 5 mm long, spreading at 45°. *Seed* \pm 7 mm long, 3 mm broad, black, shining; aril for the most part black.

SPECIMENS EXAMINED

CAPE—3119 (Calvinia): at Kaisersfontein turn off from main van Rhynsdorp-Nieuwoudtville road (-AC), 26/8/1976, *Goldblatt* 3966 (MO).

—3218 (Clanwilliam): Nardouw Kloof, Clanwilliam Division (-BB), -/9/1947, *Stokoe s.n.* (SAM 64121); 6 km north of Papkuilsfontein, near Aurora, Piquetberg Division (-CB), 76 m (250 ft.) alt., 11/8/1977, *Williams* 2328 (NBG, K, MO, PRE), 16/11/1977, *Williams* 2393 (NBG, K, PRE, MO, S); 1.6 km south of Aurora turn off, Piketberg Division, 300 ft. alt., 16/11/1977, *Williams* 2394 (NBG, BOL, MO, PRE); near Sauer, Piquetberg Division (-DC), 6/11/1963, *Esterhuysen* 30527 (BOL), 10/9/1944, *Steyn* 549 (NBG), -/10/1943, *Compton* 15097 (NBG).

—3219 (Wupperthal): on the road from Citrusdal to the Cold Bokkeveld near Allandale, Clanwilliam Division (-CA), 1 950 ft. alt., 7/11/1974, *Williams* 1920 (NBG); Thee Rivier Kloof, 15 miles S. of Citrusdal, Clanwilliam Division, -/4/1949, *Stokoe s.n.* (SAM 64139).

—3318 (Cape Town): Darling along the Bokbaai Road, Malmesbury Division (-AD), -/9/1940, *Esterhuysen* 4860 (BOL); between Mamre and Ysterfontein, Malmesbury Division, -/8/1931, *L. Bolus s.n.* (BOL 21297); near Ysterfontein, Malmesbury Division, -/7/1938, *Esterhuysen* 2775 (BOL); Tiny Vorster Nature Reserve, Darling, Malmesbury Division, 380 ft. alt., 6/12/1977, *Williams* 2409 (NBG); Darling, Malmesbury Division, 23/8/1947, *Compton* 19887 (NBG); Darling Flora Reserve, Malmesbury Division, 24/7/1956, *Winkler* 111 (NBG);

Malmesbury (-BC), 28/9/1943, *Compton 14987* (NBG); banks of Berg River near Gouda in sand, Tulbagh Division (-BD), 25/5/1952, *Esterhuysen 20161* (BOL, LD); Kalabaskraal, Malmesbury Division (-DA), 27/7/1971, *Negin 26* (NBG); in hard sandy soil between Klipheuwel and Durbanville, Bellville Division (-DC), 19/4/1935, *Acock 4269* (S); Bottellary, Stellenbosch Division (-DD), 18/1/1941, *Compton 10377* (NBG).

—3319 (Worcester): In lapidosis (altit. 3) laterum montium prope Tulbagh (-AC), -/11/-, *Ecklon & Zeyher 845* ex parte (C, G, GOET, S, SAM); Ad montes vallis Tulbagh apud Waterfall, -/11/-, *Ecklon & Zeyher 846* ex parte fide Sonder (S, SAM); Tulbagh Waterfall, Tulbagh Division, 600 ft. alt., 9/10/1975, *Williams 2104* (NBG); Drakenstein, Paarl Division (-CA), 13/12/-, *Roxburgh s.n.* (G); Wemmershoek Valley, slopes of W. mountains, Paarl Division (CC), 16/2/1940, *Esterhuysen 4084* (BOL).

—3418 (Simonstown): 1,6 km from Faure at St Raphaels, Stellenbosch Division (-BA), 50 ft. alt., 28/8/1973, *Williams 1858* (NBG).

Without locality: Thunberg (C), *Thunberg 5709* ex parte (UPS), *Zeyher 288* (G), *Drège 7137* (G, K, S).

DISTRIBUTION, VARIATION AND BIOLOGY

The main centre of distribution of this species lies in an area to the east of the Piketberg, from Sauer in a north-westerly direction to just beyond Papkuilsfontein. Here plants occur frequently and have plainly not been burnt for a long time. Elsewhere, as far as can be seen in all the outlying areas, the plant is rather rare being limited to a few individuals only. Plants from these outlying populations often have thicker leaves (*Williams 1858*, *Esterhuysen 20161*). Plants in the Darling Wild Flower Reserve differ in growing only about 300 mm tall, probably due to heavy grazing, the more normal height elsewhere being from 1–1,5 m (*Williams 2409*). The spreading cup-like disc exuding nectar indicates that these plants are most probably pollinated by insects and the rather large black seeds are as usual ejected by a trigger mechanism when ripe. Regeneration takes place from seed but no observations have as yet been made on whether or not this plant will regenerate from the stump after fires although the appearance of its stout rootstock indicates that it could probably do so. Most areas where *D. pedicellata* is found are either being invaded by introduced Acacias or being strip ploughed for agricultural purposes.

DISCUSSION

The open flower with its sinuate disc far exceeding the ovary at once places this plant in the genus *Diosma*. Its general appearance, with linear-lanceolate leaves and flowers produced in much reduced racemes, has led to its being placed

with *Diosma hirsuta* L. in some herbaria. However *Diosma pedicellata* is a distinct species and differs in being usually a tall stiff much-branched shrub, many-stemmed at base, having leaves petiolate with a narrow midrib when dry and the apex with a straight point; flowers 7 mm diam.; calyx glabrous; petals spreading, glabrous, narrowly sessile with margins irregular; fruit becoming pedicellate above the calyx. In *D. hirsuta* the petals persist for a long time at the base of the ripening fruit, a character often seen on herbarium material but in *D. pedicellata* the petals soon delapse and are never seen to be associated with the ripening fruit. *D. pedicellata* is perhaps more closely related to *Diosma aspalathoides* Lam. which occupies a rather similar habitat in deep sandy soil mostly in the vicinity of Mamre. However *D. aspalathoides* can be distinguished by its larger flowers 9–10 mm diam., with petals 3 mm broad and by its leaves which are often sharply recurved at the apex. Another species with a superficially similar appearance and which occupies a habitat somewhat further to the north is *Diosma acmaeophylla* E. & Z. It has similar large fruits with long horns that are also pedicellate above the calyx but it can be distinguished by having leaves sessile not petiolate and by the minute pubescence on the petals and calyx.

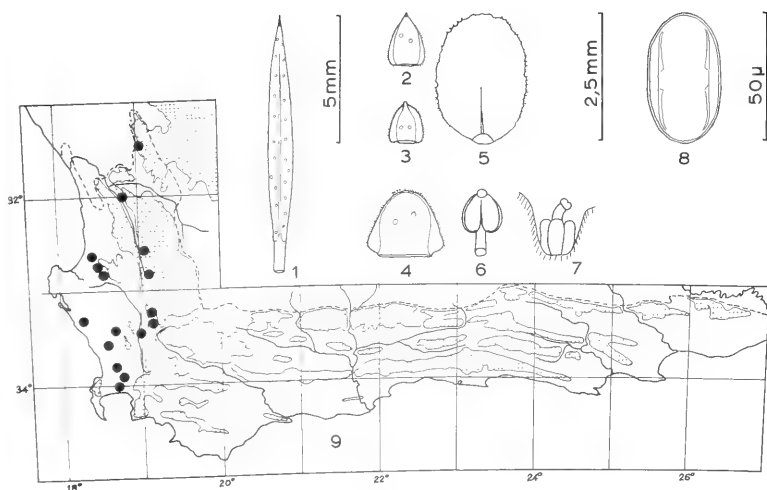


FIG. 14

Diosma pedicellata: 1, leaf. 2, bract. 3, bracteole. 4, calyx lobe. 5, petal. 6, anther. 7, gynoecium. 8, pollen. 9, distribution.



FIG. 15

Diosma pedicellata: Flower showing the typical sinuate disc.

Diosma strumosa Williams, sp.nov. propria propter fructum strumosum profunde foveatum, petalia longiora recurva, antheras vinosas, discum vinosum, stylum et fila pilis minutis sparsis vestita.

Frutex 0,8–1,2 m, erectus, ad basin monocaulis. *Rami* erecti, rigidi, glabri, pauci. *Ramuli* erecti, brevi, minute puberuli, graciles. *Folia* 2,6–6,2 mm longa, 1–1,2 mm lata, lanceolata, obtusa, sessilia, sub-erecta, alterna, omnino minute puberuli, indistincte glanduloso-punctata. *Inflorescentia* terminalis, solitaria vel bini; *flos* 8–10 mm diam., albus, in medio vinosus; *calyx* sessilis, puberulus. *Bractea* 1,3 mm longa, 1,1–1,2 mm lata, ovata, obtusa, tota puberula, marginibus ciliolatis ad basin anguste translucentibus; apex incrassatus. *Bracteolae* duae, 1,3 mm longae, 1 mm latae, sub-ovatae, obtusae, totae puberulae, marginibus ciliolatis ad basin late translucentibus. *Sepala* quinque, 1,9–2 mm longa, 1,4–1,5 mm lata, deltoidea, obtusa, tota puberula, marginibus ciliolatis ad basin late translucentibus; apex incrassatus, elevatus, viridus. *Petala* quinque, 4,1–5 mm longa, 2,1–2,2 mm lata, lanceolata, acuta, sessilia, marginibus ad basin sparsim ciliolatis; apex incrassatus, extus puberulus. *Staminodia* quinque, 0,1 mm diam., globosa, vinosa, vestigialia. *Fila* quinque, 2,1 mm longa, pilis minutis sparsis vestita. *Antherae* quinque, ante anthesin 1 mm longae, 0,7 mm latae, vinosae, glandula sub-immersa coronata. *Pollen* 51 μ longum, 25 μ latum, oblongum. *Discus* sinuato-crenulatus, succulentus, vinosus, patens, ovarium magnopere excedens, nectarifer. *Stigma* 0,3

mm diam., capitellatum, rubescens. *Stylus* ab initio deflexus deinde erectus, 1,7 mm longus, rubescens, pilis minutis sparsis vestita. *Ovarium*, 5-carpellatum, 0,6 mm longum, 0,8 mm diam., glabrum, truncatum. *Fructus* 5-carpellatus, 7 mm longus, 8 mm trans apices, sessilis; *carpella* minute puberula, strumosa, profunde foveata; *cornua* 2 mm longa, patentia. *Semen* 3,8–4 mm longum, 1,7–2 mm latum, piceum, nitens; arillus fasciatus.

Type: CAPE—3320 (Montagu): Soutkloof, 11 km north of the main road near Barrydale (-DC), 760 m alt., 28/6/1977, Williams 2314 (NBG, holotype: BOL, K, L, M, MO, PRE, S, isotypes).

A collection made by J. P. H. Acocks in 1959, housed in the National Herbarium at Pretoria, exhibiting very peculiar warty fruits, drew my attention to this plant in 1975. However it was not until this year, when, acting upon information very kindly obtained by Mr Hugh Taylor directly from Mr Acocks that this plant was successfully rediscovered.

Shrubs 0,8–1,2 m tall, erect, arising from a single stem at ground level. *Branches* erect, rigid, glabrous, few in number; *bark* smooth, greyish-brown. *Branchlets* erect, minutely puberulous, fairly slender, not very numerous, short due to grazing by animals. *Leaves* 2,6–6,2 mm long, 1,1–2 mm broad, lanceolate, obtuse, fairly erect, sessile, alternate, minutely puberulous on all sides, indistinctly gland-dotted along either side of the midrib and along the margins, turgid on the inside when fresh. *Inflorescence* terminal, solitary or with a second flower closely adjacent; *flower* 8–10 mm diam., with white petals spreading from the wine-coloured disc; *calyx* puberulous, sessile. *Bract* 1,3 mm long, 1,1–1,2 mm broad, ovate, obtuse, puberulous on all sides; margins ciliolate, narrowly translucent below; apex thickened. *Bracteoles* two, 1,3 mm long, 1 mm broad, sub-ovate, obtuse, puberulous on all sides; margins ciliolate, broadly translucent below. *Calyx lobes* five, 1,9–2 mm long, 1,4–1,5 mm broad, deltoid, obtuse, rather whitish, puberulous on both surfaces; margins ciliolate, broadly translucent below; apex thickened, elevated, green. *Petals* five, 4,1–5 mm long, 2,1–2,2 mm broad, lanceolate, acute, sessile, often persisting; margins sparsely ciliolate in the lower third; apex thickened, puberulous outside. *Staminodes* five, 0,1 mm diam., globose, wine-coloured, vestigial, situated towards the outer margin of the disc on the elevated segments of the disc. *Filaments* five, 2,1 mm long, acicular, pinkish, clothed with a few minute hairs, spreading widely after anthesis. *Anthers* 1 mm long, 0,7 mm broad, wine-coloured; apical gland semi-immersed, dark wine-coloured. *Pollen* 51 μ long, 24 μ broad, oblong. *Disc* sinuate-crenulate, fleshy, wine-coloured, spreading wide open, exceeds the ovary by a long way. *Stigma* 0,3 mm diam., capitellate, reddened. *Style* at first deflexed, becoming 1,7 mm long, erect, pinkish, persisting, clothed with a few minute hairs in the lower half. *Ovary* 5-carpellate, 0,6 mm long, 0,8 mm diam., glabrous, truncate. *Fruit* 5-carpellate, 7 mm long, 8 mm across the tips of the horns, sessile; *carpels* minutely puberulous,

lumpy with gland dots in deep pits; *horns* 2 mm long, spreading 45° , with an immersed apical gland. *Seed* 3,8–4 mm long, 1,8–2 mm broad, black, shining; aril with narrow black stripes.

SPECIMENS EXAMINED

CAPE—3320 (Montagu): 8,3 miles NNW of Barrydale, mountain rhenosterveld, occ. on S. aspect, 4 ft. (-DC), 2 300 ft., 29/7/1959, *Acocks* 20546 (PRE); Southkloof, 11 km north of the main road near Barrydale, 760 m (2 500 ft.) alt., 28/6/1977, *Williams* 2314 (NBG, BOL, K, L, M, MO, PRE, S).

DISTRIBUTION AND BIOLOGY

Diosma strumosa has as yet only been collected from a single locality near Barrydale. However, as there must be many similar habitats in the Rhenosterveld of the Little Karoo, it is quite possible that it will in due course be found elsewhere. It grows on a south-facing slope due south of the spot level 823 m (2 699 ft.) at Southkloof near Barrydale in the Swellendam Division, on soil derived from the Bokkeveld series with *Elytropappus rhinocerotis* as the dominant plant. In June flowers were to be seen in all stages of development and fruits appeared to be just about to ripen. The conspicuous open flowers, the at first deflexed style, the spent anthers that are thrust away to the outside of the flower

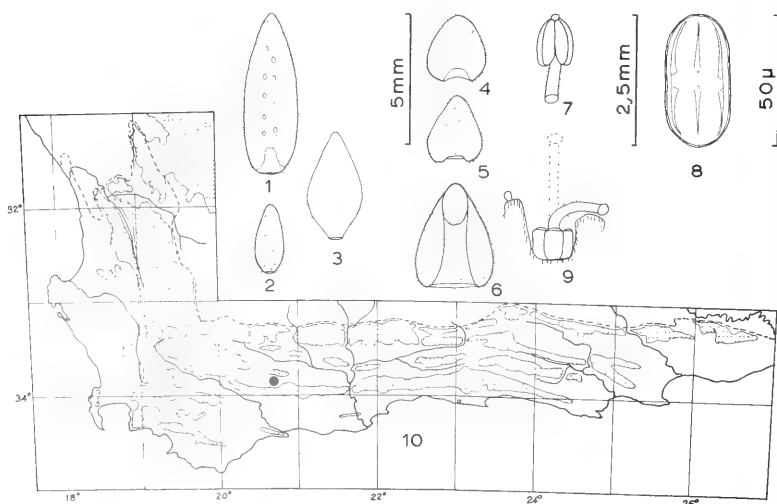


FIG. 16

Diosma strumosa: 1, large leaf. 2, small leaf. 3, petal. 4, bract. 5, bracteole. 6, calyx lobe. 7, anther. 8, pollen. 9, gynoecium and disc. 10, distribution.

and the nectariferous disc are all factors which indicate that pollination is performed by insects. Ripe seeds are ejected by the usual catapult mechanism and regeneration after fires occurs only from seed. Amongst the population examined stems were found with 8–12 annual rings indicating that these plants have regenerated since a fire about 14 years ago. It is 18 years since Acocks visited the site when the plants he observed were 4 ft. tall. The leaves have a faint sweet smell when crushed and the flowers have a faint sweet spicy smell nearer to nutmeg than to cinnamon.

DISCUSSION

The genus *Diosma* may be divided very easily into two sections. The first section in which there is absolutely no trace on the disc of any staminodes at all



FIG. 17

Diosma strumosa: Flower showing disc with staminodes.

and the second in which vestigial staminodes consisting of five sessile swellings appear on the upper outer edge of the disc. In the case in this plant these glands appear to be unusually well-developed. Other characters that place this plant in the genus *Diosma* are the wide open flower and the well-developed open disc which exceeds the ovary by a long way. Characters which exclude this plant from other genera of the *Diosmeae* are: (1) *flowers* terminal, single or paired; (2) *petals* nude; (3) *anther* with a small semi-immersed apical gland; (4) *stigma* capitellate; (5) *style* and *filament* short; (6) *ovary* 5-carpellate.

Diosma strumosa is a very distinct plant standing quite on its own in the genus with its scrofulous deeply pitted fruit, its long recurved petals, its wine-coloured anthers and disc and its style and filaments sparsely clothed with minute hairs. No other species of *Diosma* occupies a similar habitat on Bokkeveld shales, perhaps the nearest approach being that of *Diosma passerinoides* which is also peculiar in that it appears to be associated with silcrete hillocks lying on the Bokkeveld beds. The name is an illusion to the swellings on the fruit.

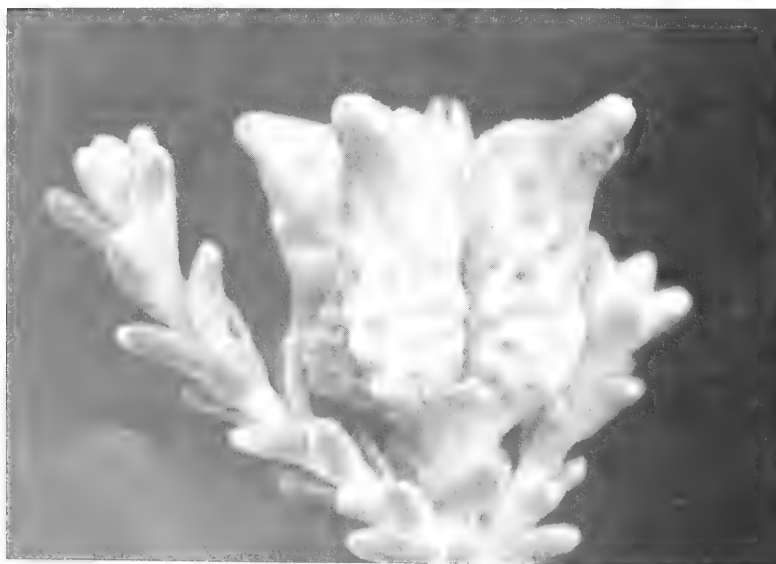


FIG. 18
Diosma strumosa: Fruit.

FLAVONOID GLYCOSIDES OF *LEUCOSPERMUM* R.BR.

C. W. GLENNIE*

(Department of Chemistry, University of the Witwatersrand, Johannesburg)

ABSTRACT

Flavonoids were surveyed (by paper chromatography) in leaves of 29 *Leucospermum* species. All samples examined contained the 3-O-galactosides and 3-O-rutinosides of quercetin and isorhamnetin while the 3-O-glucosides and 3-O-arabinosides of these aglycones were more restricted in their distribution. Myricetin 3-O-rutinoside was very restricted, occurring in only 5 species. The taxonomic significance of this distribution pattern as well as the phylogenetic implications are discussed. No cyanogenic compounds could be detected and arbutin was also absent. The phenolic lactone, leucodrin, was found in 9 of the species surveyed.

UITTREKSEL

FLAVONOIDGLIKOSIEDE VAN *LEUCOSPERMUM* R.BR

Die voorkoms van flavonoïede is deur papier-chromatografie bepaal op blare van 29 *Leucospermum* spesies. Al die monsters wat ondersoek is bevat die 3-O-galaktosiede en 3-O-rutinosiede van kwersetien en isorhamnetien terwyl die 3-O-glukosiede en 3-O-arabinosiede van hierdie aglikone meer beperk is in hulle distribusie. Mirisetien-3-O-rutinosied is baie meer beperk en het in 5 spesies voorgekom. Die taksonomiese betekenis van hierdie distribusiepatroon asook die filogenetiese implikasies word bespreek. Geen sianogeniese stowwe kon ontdek word nie en arbutien is ook afwesig. Die fenoliese laktoon, leucodrin, is teenwoordig in 9 van die spesies wat ondersoek is.

INTRODUCTION

The genus *Leucospermum* currently comprises 47 species arranged in 9 sections (Rourke, 1972). This genus is found in the sub-family Proteoideae of the Proteaceae and it is this sub-family which contains most of the species indigenous to South Africa; the other sub-family, Grevilleoideae, comprises mainly Australian species. The present survey covers 29 species representing all 9 sections described by Rourke. The principal reason for undertaking this study was to improve our knowledge of the phenolics, in particular the flavonoids, found in *Leucospermum*, and also to see if they could aid in an understanding of the classification and phylogeny of this genus.

Some *Leucospermum* spp. have been examined previously for their phenolic content. Leucodelphinidin, leucocyanidin, myricetin, quercetin, kaempferol and caffeic acid have been reported in 12 species (van Oudtshoorn, 1963; Hegnauer, 1969; Elsworth and Martin, 1971); van Oudtshoorn also reported the presence of arbutin and hydroquinone in all of the 5 species he examined.

That flavonoids are now used regularly as chemical markers in plant taxonomy

*Present address: Council for Scientific and Industrial Research, Pretoria.

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has been ably discussed by Harborne (1967, 1975). The studies mentioned above involving phenolics of the Proteaceae have used the presence or absence of leucoanthocyanins and the occurrence of the three vicinal hydroxy groups as found in myricetin as important markers. Certain flavonoid characters have been related to morphological advancement and hydroxylation patterns are important characters which can aid in establishing phylogenetic sequences. Elsworth and Martin divided their plants into four broad groups of different evolutionary advancement depending on the presence or absence of certain flavonoid patterns.

Since all previous studies were done on acid-hydrolysed material, only the flavonoid aglycones were isolated and identified. In view of this, the present study deals with aqueous methanolic extracts which contain the flavonoid glycosides. Also, many *Leucospermum* spp. not examined before have been included in this report. Along with the flavonoids the occurrence of the novel phenolic lactone, leucodrin, is tabulated and all samples were surveyed for the presence of arbutin and cyanogenic compounds.

Leucodrin has been known since 1886 but its structure was only established in recent years (Perold and Pachler, 1966). It has been isolated from various *Leucadendron* spp. and is characteristic of this genus having been found in all species examined. Conocarpin, which is a diastereoisomer of leucodrin (Perold, Hodgkinson and Howard, 1972b), is characteristic of the *Leucospermum* genus. It was first isolated and identified from *Leucospermum conocarpodendron* (Kruger and Perold, 1970). Related compounds, reflexin and conocarpic acid as well as conocarpin itself have been isolated from *L. reflexum* (Perold, Hodgkinson and Howard, 1972a).

METHODS

The plant material was collected from the Botanical Research Institute, Pretoria and the National Botanic Gardens, Kirstenbosch. Voucher specimens are deposited in the herbaria of these two institutions. The material was either air-dried and milled before extraction with 80% methanol or the fresh material was ground in a Waring Blendor directly with 80% methanol. The flavonoid glycosides were extracted, separated, purified and identified by standard procedures (Harborne, 1967). R_f values and uv spectral data for the flavonoids described are found in Table 1.

For comparison purposes two-dimensional paper chromatograms were run on Whatman No. 1 paper using PhOH (phenol:water—500:125) and 15% HOAc. To improve viewing under uv light the dried chromatograms were dipped in 3% $AlCl_3$ in methanol. This changed the flavonoids from dark absorbing spots to bright yellow spots which were more easily and reliably scored. All plant extracts were examined for leucodrin by paper chromatography on paper pretreated with 10% glycerol in methanol and run in BuOH:Tol (n-butanol:toluene-1:1 and saturated with H_2O). After air-drying, the chromatograms were sprayed with Pauly's

reagent (0.5% solution of diazotised sulphanilic acid in 10% aqueous Na_2CO_3). The extracts were also examined for hydrogen cyanide producing compounds and arbutin according to methods previously described (Glennie and Davidson, 1978).

TABLE 1.
R_f and spectral characteristics of the flavonoid glycosides of *Leucospermum*.

Glycoside	BAW	R _f (x 100) in		Phenol*
		15% HOAc	H ₂ O	
Quercetin-3-O-rutinoside	40	53	28	46
Quercetin-3-O-glucoside	75	45	10	56
Quercetin-3-O-galactoside	59	45	12	48
Quercetin-3-O-arabinoside	53	39	12	53
Isorhamnetin-3-O-rutinoside	43	61	37	79
Isorhamnetin-3-O-glucoside	65	37	05	73
Isorhamnetin-3-O-galactoside	57	45	15	75
Isorhamnetin-3-O-arabinoside	69	24	04	80
Myricetin-3-O-rutinoside	54	50	10	35

Glycoside	λ max (nm) in 80% MeOH		NaOAc	$\Delta\lambda$ max (nm) in AlCl ₃ NaOMe		H ₃ BO ₃
	Band I	Band II	Band I	Band II	Band II	Band II
Quercetin 3-O-glycoside	256 (265) [†]	358	18	62	42	22
Isorhamnetin 3-O-glycoside . . .	257 (265)	360	18	42	54	0
Myricetin 3-O-rutinoside	264	356	6	67	decomposes 20	

*BAW—organic layer of n-butanol:acetic acid:water (4:1:5); 15%HOAc—15% acetic acid; Phenol—500 g phenol in 125 g water

[†]inflection

DISCUSSION

The distribution of the different flavonoid glycosides throughout the 9 sections of *Leucospermum* are shown in Table 2. All the plants listed have been screened for all the compounds listed and only positive results presented. Blanks in the table represent negative results.

In all cases the sugars are attached at the 3-O-position. The galactosides and rutinosides of quercetin and isorhamnetin appear to be distributed uniformly throughout the genus while other glycosides have a more restricted distribution. Arabinosides of isorhamnetin and quercetin show a limited occurrence as do the glucosides of these agylcones, i.e. sections 2, 4, 5 and 6 contain arabinosides and lack glucosides while sections 1 and 3 contain glucosides and lack arabinosides. The arabinosides are more widespread than the glucosides and it should be noted that they do not usually occur together except in sections 7, 8 and 9 where

quercetin glucoside occurs with both arabinosides. Myricetin rutinoside is restricted to a few species in only four sections.

Elsworth and Martin reported kaempferol present in all *Leucospermum* species they examined and van Oudtshoorn scored most of his *Leucospermums* for kaempferol. In this present study no kaempferol could be detected but rather isorhamnetin was isolated from all 29 species. Since it is rather difficult to distinguish between kaempferol and isorhamnetin in most chromatographic systems I would suggest that it was isorhamnetin rather than kaempferol that the above authors detected. In this study the isorhamnetin agreed with authentic material in R_f values in 4 different solvents and in uv spectral characteristics; mass spectral data also indicated isorhamnetin rather than kaempferol.

Like isorhamnetin, quercetin was found in every species examined, being most commonly found as the rutinoside and galactoside. Myricetin is more restricted in its distribution and was found in only 5 out of 29 species surveyed. The *Leucospermum* spp. listed in Table 2 do not contain cyanogenic compounds nor do they contain the glucoside of hydroquinone, arbutin. *Protea* spp. are rich in arbutin (Glennie and Davidson, in press; van Oudtshoorn, 1963) but although van Oudtshoorn reported arbutin present in all *Leucospermum* spp. he surveyed, none could be detected in this study.

Two unusual phenolic lactones occur in 9 of the species surveyed; these lactones are leucodrin (Perold and Pachler, 1966) and its companion compound, leudrin (Highet, Perold and Sokoloski, 1976). Leucodrin is present in all species of *Leucadendron* tested for its presence while leudrin has a slightly more restricted distribution. Since these unusual compounds are found in both *Leucadendron* and *Leucospermum* spp. it could be suggested that both these genera are related and perhaps even have ancestry in common.

It should be noted that most species containing leucodrin and leudrin occur in the last 4 sections in Table 2. *Leucospermum* spp. which do not contain leucodrin contain its diastereoisomer, conocarpin. Since both of these compounds are rather complex molecules and also are isomers of each other, it would appear that their biosynthetic pathways did not evolve independently. It is more probable that one is a replacement character of the other, and the presumed more advanced species of this genus could have gained the ability to biosynthesize leucodrin as they lost their ability to produce its isomer, conocarpin.

On morphological and phylogeographic grounds, Rourke regards the species in Section 1 (*Crassicaudex*) as the most primitive and those in Sections 6, 7, 8 and 9 (*Leucospermum*, *Diastelloidea*, *Xericola* and *Crinitae*) as the most advanced. He suggests that it is from these advanced sections (6–9) that the possible ancestors of *Leucadendron* could have been derived. The chemical data reported in Table 2 would support this in that it is the last four sections which contain the species biosynthesizing leucodrin which is typical of *Leucadendrons* and not conocarpin which is characteristic of the presumed more primitive *Leucospermums*.

In placing their plants into four different groups, Elsworth and Martin found both *Leucospermum* and *Leucadendron* in Groups I and II (their most primitive groups) and *Leucadendron* only in Group III (a more advanced group) suggesting that at least some species of *Leucadendron* are more advanced than *Leucospermum*. The 5 species of *Leucospermum* from Rourke's Sections 6-9 that they studied were placed in Group I while the remaining 10 species from Rourke's more primitive sections were found in Group I (4 species) and Group II (6 species). This grouping was chosen mainly on the presence or absence of leucoanthocyanins and myricetin with its three vicinal hydroxy groups. In the present study most plants found to contain myricetin occurred in Rourke's more primitive sections. Work is continuing in an attempt to identify the flavonoid content as well as unusual phenolics in both *Leucospermum* and *Leucadendron*. This could possibly help clarify the position of these two genera and aid in understanding their phylogeny.

Suggesting that *Leucospermum* and *Leucadendron* are closely related and possibly had a common ancestry is contrary to the phylogenetic relationships inferred by Johnson and Briggs (1975). They suggested that *Leucadendron* and *Aulax* are derived from Aulacinae and *Leucospermum* and other genera with n:12 come from Proteinae. When the distribution of the flavonoids in *Leucadendron* is established it will aid in determining the relationships between the genera within the Proteoideae.

The Tumiditubus section consists of 8 species, 6 of which are included in this survey. At one end of the range is the *L. praecox*/*L. fulgens* group which are erect, rounded shrubs and from this the form gradually moves to the *L. spathulatum*/*L. profugum* group which are sprawling shrubs. There is also a significant change in flavonoid content as the erect shrubs contain only isorhamnetin and quercetin glycosides while the sprawling shrubs at the other end of the scale do not contain quercetin glucoside but rather myricetin rutinoside and leucodrin with a gradual transition between the two extremes.

It would be worthwhile to extend this study to as many taxa as possible within the Proteoideae for several reasons. The flavonoid patterns could be of value in determining the relationships between the various taxa within this sub-family and also in establishing their phylogeny. Since the Proteaceae appears to be rich in unusual phenolic compounds it would certainly be worthwhile to survey as many of its members as possible for these novel compounds. Lastly, it would be interesting to examine Grevilleoideae in the same manner and see how the two sub-families compare with each other.

ACKNOWLEDGEMENTS

Professor G. W. Perold (Department of Chemistry, University of the Witwatersrand) is thanked for his encouragement and for his support of this work. The Director, Botanical Research Institute, Pretoria, and Dr J. P. Rourke, National

Botanic Gardens, Kirstenbosch, are thanked for providing plant material and the latter is thanked for helpful discussions.

TABLE 2.

Distribution of Phenol Glycosides in <i>Leucospermum</i> Species											
Species	1	2	3	4	Compound						
	5	6	7	8	9	10	11				
Sect. 1. CRASSICAUDEX Rourke											
<i>L. saxosum</i> S. Moore	+	+	+	+			+	+			
<i>L. cuneiforme</i> (Burm. f.) Rourke	+	+	+	+			+	+			
<i>L. innovans</i> Rourke	+	+	+	+			+	+			
Sect. 2. CONOCARPODENDRON Buek ex Endl											
<i>L. conocarpodendron</i> (L.) Buek	+	+	+	+	+	+					
<i>L. glabrum</i> Phillips	+	+	+	+	+	+					
<i>L. pluridens</i> Rourke	+	+	+	+	+	+					
Sect. 3. TUMIDITUBUS Rourke											
<i>L. praecox</i> Rourke	+	+	+	+			+	+			
<i>L. fulgens</i> Rourke	+	+	+	+			+	+			
<i>L. muirii</i> Phillips	+	+	+	+			+	+			
<i>L. erubescens</i> Rourke	+	+	+	+				+			
<i>L. urticulosum</i> Rourke	+	+	+	+			+			+	+
<i>L. spathulatum</i> R. Br.	+	+	+	+			+	+	+	+	+
Sect. 4. BREVIFILAMENTUM Rourke											
<i>L. vestitum</i> (Lam) Rourke	+	+	+	+	+	+					
<i>L. tottum</i> (L.) R. Br.	+	+	+	+	+	+					
<i>L. lineare</i> R. Br.	+	+	+	+	+	+					
<i>L. cordifolium</i> (Salisb. ex Knight)											
Fourcade	+	+	+	+	+	+			+		
<i>L. cordatum</i> Phillips	+	+	+	+	+	+					
Sect. 5. CARDINISTYLUS Rourke											
<i>L. formosum</i> (Andr.) Sweet	+	+	+	+	+	+					
<i>L. catherinae</i> Compton	+	+	+	+	+	+					
<i>L. queinzii</i> Meisn.	+	+	+	+	+	+			+		
<i>L. reflexum</i> Buek ex Meisn.	+	+	+	+	+	+			+		
Sect. 6. LEUCOSPERMUM											
<i>L. tomentosum</i> (Thunb) R. Br.	+	+	+	+	+	+			+	+	+
Sect. 7. DIASTELLOIDEA Phillips											
<i>L. calligerum</i> (Salisb. ex Knight)											
Rourke	+	+	+	+	+	+	+			+	+
<i>L. royenifolium</i> (Salisb. ex Knight)											
Stapf	+	+	+	+	+	+	+			+	+
<i>L. truncatulum</i> (Salisb. ex Knight)											
Rourke	+	+	+	+	+	+				+	+
<i>L. bolusii</i> Gandoger	+	+	+	+	+	+	+			+	+
Sect. 8. XERICOLA Rourke											
<i>L. alpinum</i> ssp. <i>amoenum</i> Rourke	+	+	+	+	+		+			+	+
Sect. 9. CRINITAE Phillips											
<i>L. oleifolium</i> (Berg) R. Br.	+	+	+	+	+	+	+				
<i>L. mundii</i> Meisn.	+	+	+	+	+	+	+			+	+

KEY

1. Quercetin 3-O-rutinoside;
2. Isorhamnetin 3-O-rutinoside;
3. Quercetin 3-O-galactoside;
4. Isorhamnetin 3-O-galactoside;
5. Quercetin 3-O-arabinoside;
6. Isorhamnetin 3-O-arabinoside;
7. Quercetin 3-O-glucoside;
8. Isorhamnetin 3-O-glucoside;
9. Myricetin 3-O-rutinoside;
10. Leucodrin;
11. Leudrin.

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TEN MORE NEW SPECIES OF *LACHENALIA* (LILIACEAE)

W. F. BARKER

(*Bolus Herbarium, University of Cape Town*)

ABSTRACT

Ten new species of *Lachenalia* are described, and the characters of the ripe seeds are used as additional diagnostic features.

UITTREKSEL

'N VERDERE TIEN NUWE *LACHENALIA* SOORTE (LILIACEAE)

Tien nuwe *Lachenalia* spesies word beskryf. Die eienskappe van die ryp sade word as aanvullende diagnostiese kenmerke in die genus voorgestel.

INTRODUCTION

Of the ten new species described two, *L. macgregori* and *L. margaretae* are only known from the type localities, while *L. polypodantha*, as far as is known, has a very restricted distribution. Six of the species have seeds with terminal inflated arils, while four fall into the group with terminal ridged arils, however in *L. polypodantha* the entire testa is wrinkled into an irregular pattern of ridges, a character which at present is only known to be shared by *L. polyphylla* Bak., *L. patula* Jacq. and *L. trichophylla* Bak.

***Lachenalia bolusii* Barker, sp. nov.**

Distinguitur folio unico ovato lanceolato vel lorato plerumque marginem undulato vel crispato, basi amplexententi supra marronino fasciata basin versus magentea, pedunculo pergracili, inflorescentia racemosa laxa, floribus parvis campanulatis vel urceolatis, segmentibus externis basi pallide caeruleis, supra albis gibbosis fuscis, segmentibus internis paulo longioribus albis apicem fusco-maculatis, staminibus segmentibus internis aequantibus, seminibus globosis, arillo inflato terminale mensure medio.

Plant up to 340 mm high. *Bulb* ovate 10–20 mm diam.; outer tunics membranous, brown. *Leaf* 60–160 mm long; blade ovate-lanceolate to lorate 30–140 mm long, 7–20 mm broad near base, blue-green banded with maroon near base on lower side, margin undulate or crisped, with faint traces of papillae on margins near base; clasping base 20–120 mm long, with faint traces of papillae in the upper part and with maroon bands which shade to magenta toward the base. *Peduncle* very slender, up to 220 mm long above the clasping base, densely and

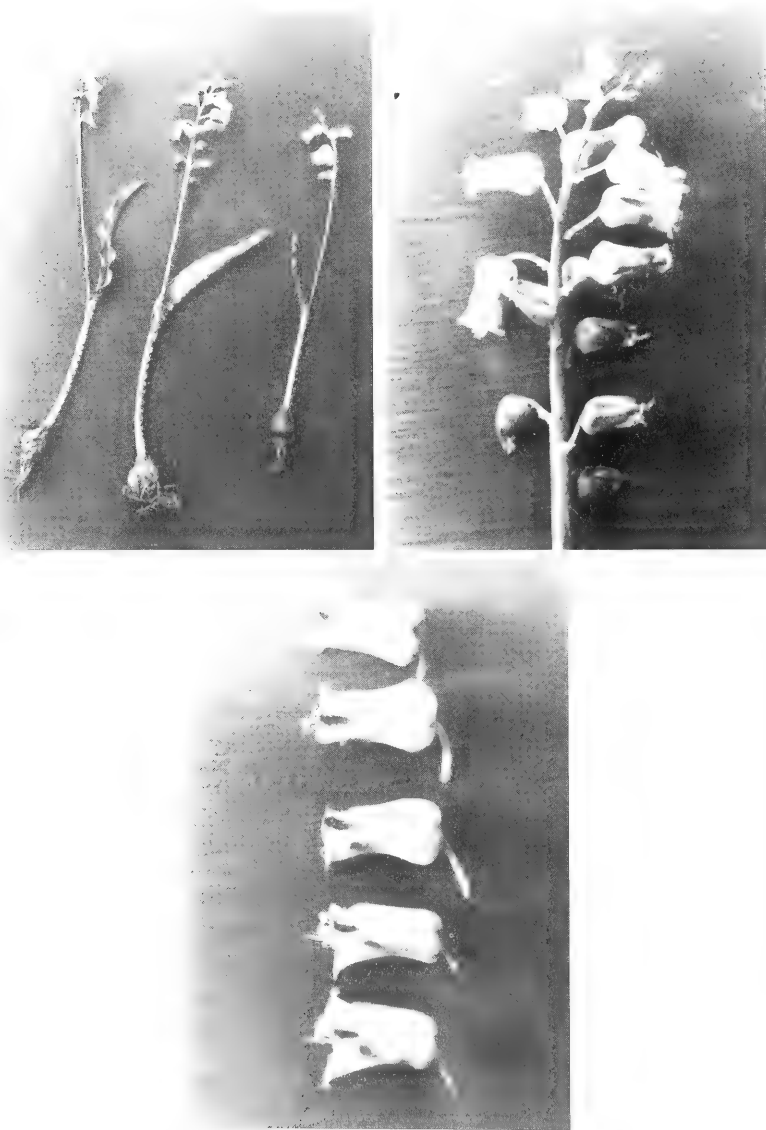


FIG. 1 a,b,c
Lachenalia bolusii: a. three plants; b. inflorescence; c. flowers. (Hall 4098).

minutely spotted or suffused with maroon. *Inflorescence* racemose very lax, usually few-flowered, up to 90 mm long and 20–30 mm diam.; pedicels up to 6 mm long; bracts ovate obtuse, membranous; flowers narrow campanulate to slightly urceolate, cernuous. *Perianth* up to 9 mm long 5 mm diam. at base; tube 2 mm long, pale blue; outer segments ovate, blue at base, white, with brownish gibbositities; inner segments a little longer than outer, obovate obtuse, white with a reddish-brown spot near apex, apex recurved; stamens as long as inner segments. *Ovary* globose 3 mm long; style 6 mm long. *Capsule* obovate 8 mm diam.; seed globose, aril inflated, terminal, medium length.

DIAGNOSTIC CHARACTERS

Lachenalia bolusii is characterised by its very slender habit, its single leaf with an ovate-lanceolate to lorate blade, and its tightly clasping banded base. The inflorescence is racemose, very lax and few-flowered, and the campanulate to urceolate flowers are cernuous, and the stamens are included. The seeds have an inflated, terminal aril.

Type Material: CAPE PROVINCE—2917 (Springbok): Klipfontein (-BA), Aug. 1883, H. Bolus 6592 (BOL, holo.; K, iso.).

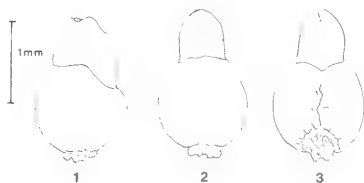


FIG. 2

Lachenalia bolusii: 1. seed side view; 2. seed from above; 3. seed from below.

The affinities of this taxa have caused considerable thought and speculation. Should it be placed in the *L. unifolia* complex which already includes a number of varieties, or could it be regarded as a semi-glabrous variety of *L. hirta*, as it has vestiges of hair bases or papillae on the leaf, especially in the collections from the Bidouw Valley area.

On examination, the seeds which have a short, inflated terminal aril, were found to be distinct from those of either *L. unifolia* or *L. hirta*, which both have seeds with an almost obsolete ridged aril. It has therefore been described as new, and named after Dr. H. Bolus.

The distribution of *L. bolusii* is along the mountains from Clanwilliam to Namaqualand, and its habitat the rocky mountain slopes. Its flowering time is during August and September.

After unusually good rains in 1977, the first records of the species were made from the Richtersveld in September, on an expedition to the region by Oliver, Tölken and Venter. Unlike stunted plants usually associated with the Richtersveld, these specimens were tall, and similar to those from the more southern localities.

SPECIMENS EXAMINED

- CAPE PROVINCE—2816 (Oranjemund): Kodaspiek N. Richtersveld (-BB), 9/1977, *Oliver, Tölken and Venter* 429 (PRE).
 —2817 (Vioolsdrif): Cornellsberg in Stinkfonteinberg in Richtersveld (-CA), 9/1977, *Oliver, Tölken and Venter* 708 (PRE).
 —2917 (Springbok): Klipfontein (-BA), Aug. 1883, *H. Bolus* 6592 (BOL, holo.; K, iso.); 19/8/1971, *Hall* 4098 (NBG); Steinkopf (-BC), Aug. 1925, *Marloth* 6768 (PRE); 24/8/1959, *Barker* 9041 (NBG); Spektakel (-DA), 25/8/1941, *Barker* 1123 (NBG); 25/8/1941, *Esterhuysen* 5876 (BOL, NBG).
 —3119 (Calvinia): Top of Vanrhyns Pass (-AC), 21/8/1959, *Lewis* 5462 (NBG).
 —3219 (Wuppertal): Bidouw Berg (-AA), 26/8/1896, *Schlechter* 8689 (BOL, G, K, L, PRE, Z); 26/8/1896, *Schlechter* 8687 (BM, K); Biedouw Valley, 24/8/1967, *Thompson* 350 (PRE); Pakhuis Pass, Sept. 1933, *Leipoldt s.n.* sub. BOL 20784 (BOL); Near Pakhuis Pass, Sept. 1933, *Leipoldt s.n.* sub. (BOL).

Lachenalia latimerae Barker, sp. nov.

Distinguitur foliis 2 linearibus vel linearo-lanceolatis attenuatis supra canaliculatis flaccidis, basi laxe amplexentibus, minute magentea punctata, inflorescentia racemosa, floribus campanulatis cernuis pallide roseis vel lilacinis, segmentibus internis externis paulo brevioribus, apicibus recurvatis, staminibus exsertis, seminibus globosis, arillo jugoso terminale breve vel mensura medio.

Plant up to 280 mm high. *Bulb* globose up to 20 mm diam.; outer tunics membranous, brown. *Leaves* 1–2 very rarely 3, up to 250 mm long; blade up to 200 mm long and 20 mm broad at base, green, linear, to linear-lanceolate, attenuate channelled above, flaccid, spreading; clasping base 30–50 mm long, plain or minutely spotted with magenta. *Peduncle* short 30–40 mm long above the clasping base, minutely spotted with red-brown. *Inflorescence* racemose, many-flowered 70–170 mm long, 25–35 mm diam.; pedicels spreading, flowers cernuous; bracts minute, lanceolate. *Perianth* campanulate, up to 10 mm long, tube 2 mm long, pale pink or lilac; outer segments ovate 5 mm long, pale pink or lilac with greenish-brown gibbositities; inner segments obovate 7 mm long, 5 mm broad, with apex recurved, pale pink or lilac with a pinkish-brown spot at apex. *Stamens* exserted up to 13 mm long, white. *Ovary* ovate 2 mm long; style up to 10 mm long, white. *Capsule* obovate, membranous; seed globose, aril ridged, terminal small.



FIG. 3

Lachenalia latimerae: 1. flower side view; 2. flower from below; 3. transverse section of flower; 4. flower front view; 5. lateral outer perianth segment; 6. upper outer perianth segment; 7. lower inner perianth segment; 8. lateral inner perianth segment; 9. gynoecium, all $\times 3$. (Salter Hort. NBG 1987/1936).

DIAGNOSTIC CHARACTERS

Lachenalia latimerae is characterised by its many-flowered lax inflorescence, and campanulate, cernuous flowers with well-exserted stamens. Its two linear, attenuate, channelled, flaccid leaves are longer than the inflorescence, and its seeds belong to the group with a ridged, terminal, short or medium aril.



FIG. 4

Lachenalia latimerae: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3324 (Steytlerville): Ferndale Farm, Patensie (-DD), July 1949, *M. Courtenay-Latimer s.n.* sub. NBG 72287, Hort. NBG 1267/1948 (NBG, holo.).

In 1936 Paymaster Captain T. M. Salter collected some bulbs of a *Lachenalia* species which he presented to the National Botanic Gardens, Kirstenbosch. When they flowered on 18th August 1941, a specimen was illustrated and herbarium specimens were preserved in the Compton Herbarium. In August 1948 Miss M. Courtenay-Latimer sent in some bulbs from Ferndale Farm, Patensie which flowered in the Nursery at Kirstenbosch in July 1949. These proved to be the same species as the Congo Cave plant, and several other collections have been received from the same area, including some very fine specimens from Col. D. R. Bayliss in September 1976.

Lachenalia latimerae has an affinity with *L. juncifolia* Bak. in the shape and set of the flowers, but the two species differ markedly in the shape of their leaves, which is filiform terete in the latter.

Incomplete material of two other collections, one from near the Gouritz River and the other from Seven Weeks Poort, may eventually be found to be conspecific, and the indications are that the distribution of the species is much wider, and requires further investigation.

The species is named in honour of Dr. M. Courtenay-Latimer, recently retired Director of the East London Museum of Coelacanth fame, who for many years played an active role in the conservation of the South African flora, particularly that of the Southern and Eastern Cape.

SPECIMENS EXAMINED

CAPE PROVINCE—3322 (Oudtshoorn): near Cango Caves (-AC), 21/8/1941, *Salter s.n.* sub. NBG 72236, Hort. NBG 1987/1936 (NBG).
—3324 (Steytlerville): Ferndale Farm, Patensie (-DD), August 1948, *M. Courtenay-Latimer s.n.* sub. NBG 72422, Hort. NBG 1267/1948 (NBG); July 1949, *M. Courtenay-Latimer s.n.* sub. NBG 72287, Hort. NBG 1267/1948 (NBG); 24/9/1949 (fruiting), *G. G. Smith 7186a*, Hort. NBG 1064/1949 (NBG); 16/8/1950, *G. G. Smith 7168a*, Hort. NBG 1064/1949 (NBG); Patensie, 9/9/1976, *Bayliss 7102* (NBG).

***Lachenalia macgregori* Barker, sp. nov.**

Distinguitur foliis 2 proteranthis anguste linearibus canaliculatis cyaneis graminiformibus basi rubro-fusca suffusa maculata vel fasciata, inflorescentia racemosa, floribus patentibus late campanulatis, segmentibus externis albis, marroneis late vittatis, segmentibus internis marroneis margine pallidioribus, staminibus exsertis, filamentis expansis marroneis, seminibus globosis, arillo jugoso terminale reducto.

Plant 160–360 mm high. *Bulb* 20–25 mm diam., white with thin membranous brown tunics, and with membranous remnants of old spotted bases of the proteranthus leaves forming a short neck. *Leaves* 2 proteranthus, linear canaliculate, suberect to spreading, up to 220 mm long and 7 mm broad, blue-green without markings on the upper two-thirds, lower third suffused with pale maroon or minutely spotted or banded with red-brown, clasping bases up to 60 mm long, *Peduncle* up to 250 mm high, usually less, slender, minutely spotted with red-brown, as long or longer than the inflorescence. *Inflorescence* racemose, up to 130 mm long, sterile portion short; bracts minute, obtuse; pedicels 2–5 mm long, pale at base, maroon below the flowers, spreading. *Flowers* up to 9 mm long, widely campanulate; tube 2 mm long, white; outer segments 3–5 mm long, ovate, concave at base and slightly spreading toward the apex, white with a broad central maroon stripe, which continues halfway down the tube; inner segments 5–7 mm long, obovate, spreading slightly more than the outer, maroon, paler toward the sides. *Stamens* well exserted, up to 10 mm long, spreading, filaments maroon. *Ovary* obovate 2 mm diam., green; style 7–9 mm long, maroon. *Capsule* obovoid, narrowed at the base, 3 mm diam., membranous; seed globose, shining, aril ridged, reduced to almost absent.

DIAGNOSTIC CHARACTERS

Lachenalia macgregori belongs to a small group of species which have proteranthous leaves. In nature the leaves appear in April, and have died down completely before the flowers appear in late October or early November. The two linear, canaliculate leaves are grass-like and scarcely succulent. Its flowers are

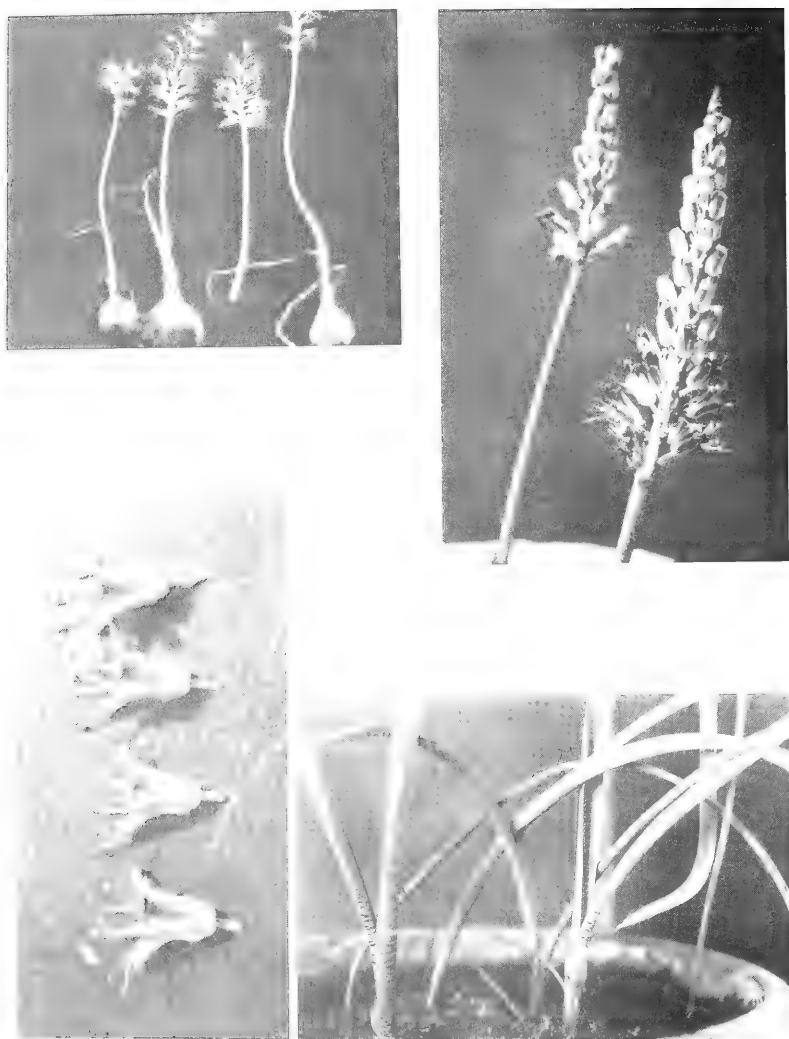


FIG. 5

Lachenalia macgregori: a. plants in flowering stage; b. young inflorescences; c. flowers; d. leaf-bases. (Barker 9766).

distinctive in colouring, having a wide maroon stripe down the centre of the white outer segments extending on to the tube, while the inner segments are maroon, becoming paler at the sides. The species appears to be most closely to *L. pearsonii* (Glover) Barker, resembling it in the shape of the flowers and the leaves, however the latter are synanthous in *L. pearsonii*.



FIG. 6

Lachenalia macgregori: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3119 (Calvinia): Charles Hoek, Nieuwoudtville (-AC), 5/11/1962, *W. F. Barker* 9766 (NBG, holo., iso.).

Up to the present *Lachenalia macgregori*, a most interesting and unique species, is only known from the type locality, and has only been collected there once, on 5th November 1962. With the permission of the late Mr M. Macgregor of Glen Lyon Farm, we were able to explore the area called the Klipkoppies or Charles Hoek, where we came across it somewhat unexpectedly, as it was late in the season for *Lachenalia* species, and without leaves it was very inconspicuous. Bulbs were grown for leaves, which began to appear in early April, and the bulbs have continued to produce flowers and leaves alternately ever since.

The species has been named in honour of the Macgregor family, who have farmed in the Nieuwoudtville district for several generations, and have always been practical conservationists, setting aside large portions of their farms as private reserves. They have generously enabled botanists to collect specimens for research purposes, and have allowed members of the public to view and enjoy the exceptionally varied and beautiful floral heritage, which they have preserved for posterity.

SPECIMENS EXAMINED

CAPE PROVINCE—3319 (Calvinia): Charles Hoek (Klipkoppies) Nieuwoudtville (-AC), 5/11/1962, *W. F. Barker* 9766 (NBG, holo., iso.); 24/10/1967 *Barker* 9766 (NBG); 27/10/1970, *Barker* 9766 (NBG); (Leaves) 23/5/1970, *Barker* 9766 (NBG).

***Lachenalia margaretae* Barker, sp. nov.**

Distinguitur folio unico (raro 2) flaccido lorato immaculato vel supra maculato, inflorescentia racemosa folio breviora, floribus parvis campanulatis, segmentibus externis albis gibbosis atrofuscis, segmentibus internis vix longioribus albis apicem macula ovali atrofusca, staminibus breve exsertis, seminibus globosis, arillo inflato terminale mensure medio.

Plant dwarf, up to 120 mm high. *Bulb* globose 10–15 mm diam., with soft brown outer tunics, sometimes produced into a short neck. *Leaf* 1 occasionally 2, much longer than the inflorescence, lorate; blade spreading, flaccid, up to 190 mm long and 15 mm broad, plain green or spotted with dark brown above, tinged with maroon below; clasping base up to 30 mm long. *Peduncle* short, up to 70 mm long, slender, maroon. *Inflorescence* racemose, 20–60 mm long, few to many-flowered; bracts small acute tinged maroon; pedicels short up to 3 mm long, spreading, white; flowers small spreading. *Perianth* 5–7 mm long, campanulate; tube 1–2 mm long, white; outer segments ovate 4–5 mm long, white with comparatively large globose chocolate-coloured gibbosities; inner segments scarcely longer, obovate, white with a narrow oblong chocolate-coloured spot near the apex; stamens shortly exserted 6–7 mm long. *Capsule* obovate, membranous 5 mm diam., comparatively large; seeds few, comparatively large, globose, aril inflated, terminal, medium length.

DIAGNOSTIC CHARACTERS

Lachenalia margaretae is characterised by its one (very occasionally two) long, lorate, flaccid, spreading leaf which is spotted or plain above. The inflorescence is usually much shorter than the leaf, the flowers small, white campanulate with large chocolate-coloured gibbosities on the outer segments, and narrow oblong spots on the inner segments, which are only slightly longer than the outer. Its seed falls into the group with an inflated, terminal aril.

Type Material: CAPE PROVINCE—3218 (Wuppertal): Pakhuis Pass (-AA), 19/10/1965, *Barker 10320* (NBG, holo.); 4/12/1970, *Barker 10783* (NBG, topo.); 24/10/1972, *Barker 10783* (NBG, topo.).

Lachenalia margaretae was first discovered by Mrs Margaret Thomas on 19th October, 1965, when we stopped in the Pakhuis Pass to search for the species which has now been described as *L. esterhuysenae*. *L. margaretae* was found at a somewhat lower altitude, growing in the shade of huge overhanging T.M.S. boulders, in very shallow soil, with the flaccid leaves spreading on the ground.

Up to the present it has only been found in the type locality. A second collection was made in September, 1970 when it was in leaf, and the bulbs flowered on 4th December, 1970, and again on 24th October, 1972.

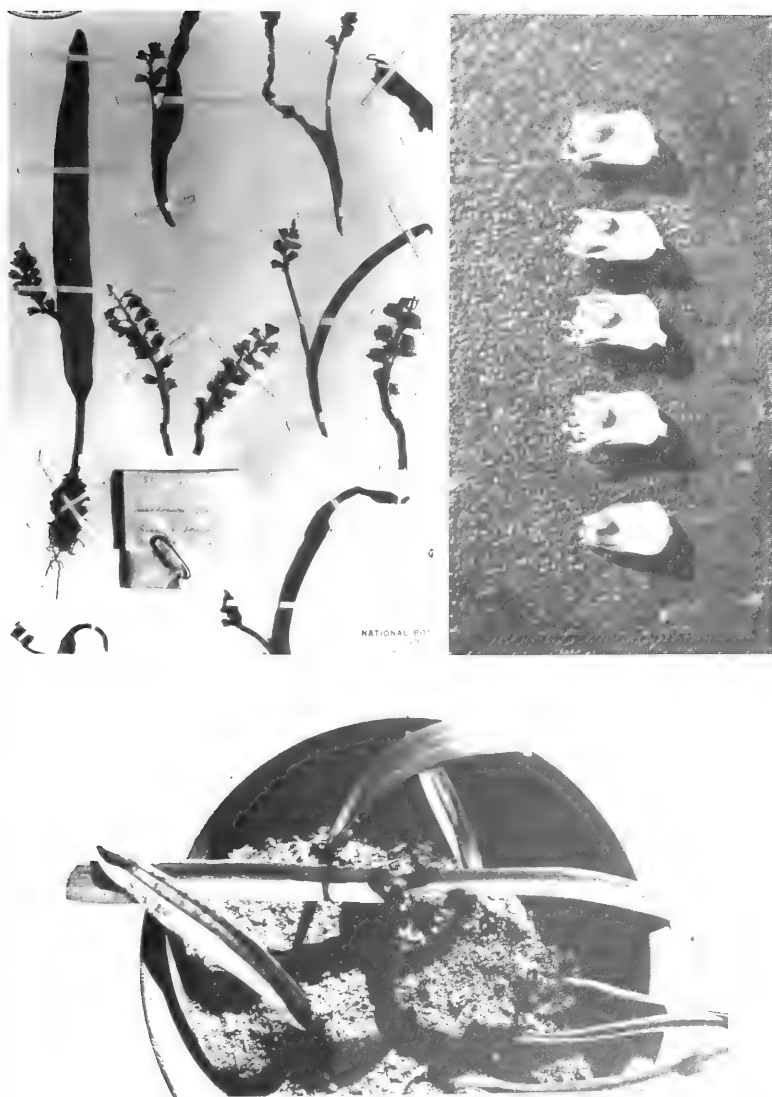


FIG. 7 a,b,c

Lachenalia margaretae: a. portion of type sheet in Compton Herbarium; b. flowers; c. leaves. (Barker 10320).

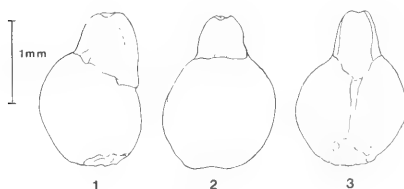


FIG. 8

Lachenalia margaretae: 1. seed side view; 2. seed from above; 3. seed from below.

The species is named in honour of Mrs Margaret Thomas, a former member of the horticultural staff at the National Botanic Gardens, Kirstenbosch, in appreciation of her invaluable assistance, in numerous ways over many years, toward my researches on the genus.

SPECIMENS EXAMINED

CAPE PROVINCE—3218 (Wuppertal): Pakhuis Pass (-AA), 19/10/1965, *Barker 10320* (NBG, holo.); 4/12/1970, *Barker 10783* (NBG, topo.); 24/10/1972, *Barker 10783* (NBG, topo.).

Lachenalia marginata Barker, sp. nov.

L. orchiioides affinis, distinguatur folio unico acute ovato vel falcato, margine incrassato coriaceo undulato, basi amplexentis fasciata, pedunculo infra inflorescentiam inflato, inflorescentia spicata, floribus suberectis vel patentibus, periantho longo angusto leviter urceolato, segmentibus externis atrofuscis gibbosis, segmentibus internis longioribus, segmentis infimis superioribus longioris, staminibus inclusis, seminibus ovatis, arillo inflato terminale mensura medio.

Plant 110–300 mm high. *Bulb* globose 10–20 mm diam., outer tunics membranous, brown. *Leaf* 1, very occasionally 2; blade spreading ovate acute to falcate up to 120 mm long, 30 mm broad at base, glaucous with faint darker blotches above, margin often undulate, thickened and coriaceous; clasping base up to 90 mm long, widening above, banded with maroon, shading to magenta toward the base. *Peduncle* up to 100 mm long above the clasping base, slightly to much swollen below the inflorescence. *Inflorescence* spicate, few to many-flowered, up to 90 mm long and 40 mm diam., flowers suberect to spreading. *Perianth* narrow urceolate 15–18 mm long, 5 mm diam. near base, tube 3 mm long, pale blue-green; outer segments oblong 7–10 mm long pale blue-green at base, shading to pale yellow-green above with dark brown gibbosities; inner segments narrowly obovate, cuneate, obtuse or emarginate, the two upper lateral segments broader 12–14 mm long, overlapping, lowest narrower and distinctly longer, with a slightly upward curve, all pale yellow, pale green down the centre; stamens



FIG. 9

Lachenalia marginata: 1. flower side view; 2. flower from below; 3. transverse section of flower; 4. flower front view; 5. upper outer perianth segment; 6. lateral outer perianth segment; 7. lower inner perianth segment; 8. lateral inner perianth segment; 9. gynoecium, all $\times 2$.

included; filaments up to 15 mm long; ovary ovate oblong, 3 mm long; style 11 mm long. *Capsule* ovoid 7 mm long, membranous; seed ovate, aril inflated, terminal, of medium length.

DIAGNOSTIC CHARACTERS

Lachenalia marginata has an affinity with *L. orchoides* (L.) Ait. but differs in having one leaf with a banded clasping base and a shorter firmer blade, with a thickened coriaceous margin which is usually undulate. The mouth of the flower is narrow and the lower inner segment protrudes beyond the two lateral upper ones while the gibbositities on the outer segments are dark brown.

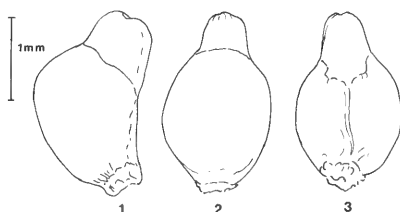


FIG. 10

Lachenalia marginata: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3119 (Calvinia): 4 m. W of Nieuwoudtville (-AC), 23/8/1950, *Barker 6463* (NBG, holo.).

The first plant of *Lachenalia marginata* to be seen, flowered at the Bolus Herbarium in June 1934 and was recorded in the accompanying painting. Unfortunately the specimen was not localised, but it has since been collected many times in sandy soil in the vicinity of Nieuwoudtville. It has also been recorded from the Matzikamma Mountain near Vanrhynsdorp, from Lorraine Farm north of Pakhuis, and as far south as Matjesrivier Farm in the Southern Cedarberg.

It falls into the large group of species having seeds with a terminal, inflated aril to which *L. orchoides* also belongs.

SPECIMENS EXAMINED

CAPE PROVINCE—3118 (Vanrhynsdorp): Matzikamma (-AB), 22/7/1940, *Martin s.n.* sub. NBG 72364, Hort. NBG 629/1938 (NBG); Klaver (-DC), 2/6/1950, *Barker 7387* (NBG).

—3119 (Calvinia): Glenridge Farm, Nieuwoudtville (-AC), 12/8/1960, *Lewis 5735* (NBG), 12/8/1961, *Barker 9433* (NBG); 23/8/1966, *Barker 10451* (NBG); 3 m W of Nieuwoudtville, July 1948, *Lewis 2408* (SAM); 23/8/1950, *Lewis 3240*

(SAM); 23/8/1950, *Barker 6465* (NBG); 4 m W of Nieuwoudtville, 23/8/1950, *Barker 6463* (NBG).

—3219 (Wuppertal): Farm Lorraine N. of Pakhuis (-AA), 23/7/1965, *Siaens s.n.* sub. NBG 84814 (NBG); Matjesrivier, Cedarberg (-AC), 26/9/1942, *Wagener 209* (NBG).

***Lachenalia martinae* Barker, sp. nov.**

Distinguitur folio unico anguste lanceolato vel lorato, margine undulato vel crispato, basi amplexenti fasciata, inflorescentia subspicata, floribus parvis patentibus vel leviter cernuis, periantho hebeti anguste urceolato, segmentibus internis externis longioribus, staminibus inclusis vel leviter exsertis, seminibus globosis, arillo inflato terminale mensure medio.

Plant up to 250 mm high. *Bulb* globose 10–20 mm diam.; outer tunics grey-brown, produced into a very short neck. *Leaf* 1, up to 120 mm long; blade suberect to spreading, narrow lanceolate to lorate, up to 100 mm long, 10–35 mm broad at base, dark green above, with longitudinal depressed veins, lower surface banded toward the centre with maroon, shading to green at the sides and apex, or sometimes entirely suffused with maroon on the entire lower surface, margins undulate or crisped; clasping base up to 50 mm long, whitish with transverse bands, maroon above shading to magenta below ground. *Peduncle* up to 160 mm long, slender, pale and minutely spotted or suffused with maroon. *Inflorescence* up to 110 mm long and 20 mm diam., subspicate, few to many-flowered, flowers spreading to slightly cernuous; pedicels 1–2 mm long; bracts with a long filiform translucent apex. *Perianth* narrow urceolate, oblong, 10–12 mm long; tube 1–2 mm long, whitish; outer segments 6 mm long, whitish, very minutely spotted with pale blue or grey, gibbosities dull greenish-brown; inner segments 9 mm long, 3.5 mm diam. at apex, shining opal-grey with dull reddish-brown zone near apex, tips slightly recurved; stamens as long as inner segments or very slightly exserted; ovary oblong, 2 mm long, bright green; style finally exserted. *Capsule* oval, membranous; seed globose, aril inflated, terminal, short.

DIAGNOSTIC CHARACTERS

Lachenalia martinae is distinguished by having a single narrow lanceolate to lorate leaf with margins undulate or crisped, and a banded clasping base. The inflorescence is subspicate, flowers small, slightly cernuous, the perianth dull-coloured, narrow urceolate, inner segments longer than the outer, and the stamens included or a little exserted. Seed globose, aril inflated, terminal, of medium length.

Type Material: CAPE PROVINCE—3218 (Clanwilliam): Alpha Farm, Olifants River Valley at Cedarberg turn off (-BD), 3/8/1937, *B. E. Martin s.n.* sub. Hort. NBG 1262/37 sub NBG 72237 (NBG, holo.).

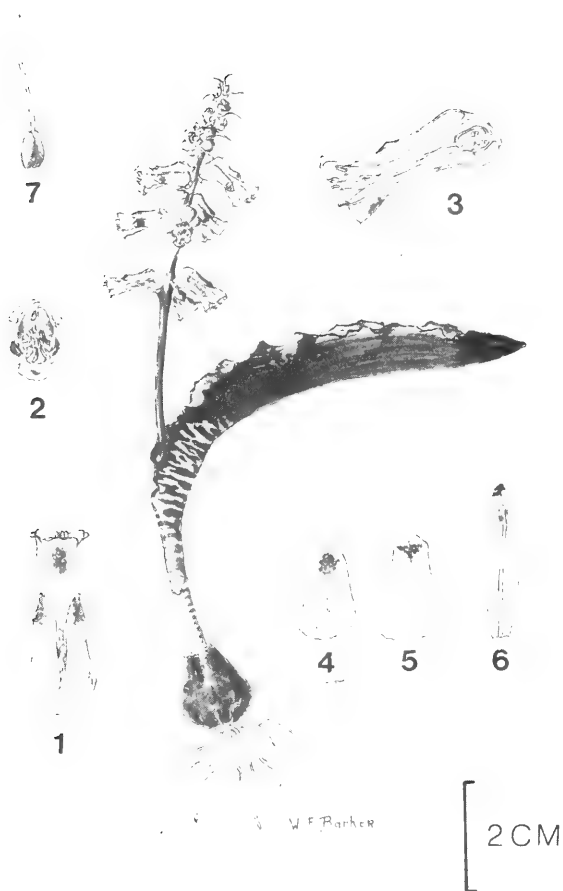


FIG. 11

Lachenalia martiniae: 1. flower from below; 2. flower front view; 3. longitudinal section of flower; 4. lateral outer perianth segment; 5. upper outer perianth segment; 6. lateral inner perianth segment; 7. gynoecium, all $\times 3$. (Martin Hort. NBG 1262/1937).

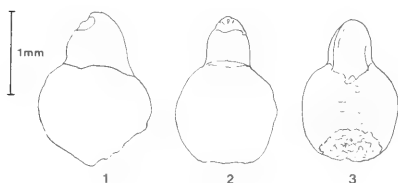


FIG. 12

Lachenalia martinae. 1. seed side view; 2. seed from above; 3. seed from below.

Lachenalia martinae has been recorded mainly from the Olifants River Valley, between Alpha Farm and Clanwilliam, but a single collection from the eastern side of the Pakhuis Pass, indicates that it may have a much wider distribution. The fact that it flowers as early as July, may be the reason why it has not been collected more often.

The species is named in honour of Miss B. E. Martin, an ardent plantswoman, who collected the type in 1937, while working at Kirstenbosch as horticulturist in charge of the bulb garden, having previously completed her horticultural training at the Dunedin Botanic Garden, New Zealand. After serving in the Middle East, Miss Martin returned to Kirstenbosch in 1945 as Secretary to the Director.

SPECIMENS EXAMINED

CAPE PROVINCE—3218 (Clanwilliam): Clanwilliam (-BB), *C. L. Leipoldt s.n.* sub. SAM 23154 (SAM); Near Clanwilliam Dam, 7/1948, *G. J. Lewis* 2421 (SAM); 7/1948, *G. J. Lewis* 2422 (SAM); Clanwilliam Dam, 7/1948, *G. J. Lewis and Davis s.n.* sub. SAM 61291 (PRE); above Clanwilliam Dam, 21/7/1977, *M. C. Botha s.n.* sub. NBG (NBG); 3 miles south of Clanwilliam, 7/1948, *D. Davis s.n.* sub. SAM 61292 (SAM); Alpha Farm, Cedarberg turn off, (-BD), 3/8/1937, *B. E. Martin s.n.* sub. Hort. NBG 1262/1937 sub. NBG 72237 (NBG). —3219 (Wuppertal); Foot of Pakhuis Pass, eastern side (-AA), 7/1948, *T. P. Stokoe s.n.* sub. SAM 61271a (SAM).

Lachenalia maximiliani Schltr. ex Barker sp. nov.

Distinguitur folio unico lanceolato immaculato, basi laxe amplexenti, inflorescentia subspicata, floribus pallidis opalescentibus suberectis vel patentibus, periantho anguste urceolato, segmentibus internis subacutis externis longioribus, staminibus segmentibus internis aequantibus, seminibus globosis, arillo jugoso breve.

Plant up to 200 mm high. *Bulb* ovate, 10–15 mm diam.; outer tunics several, leathery, dark brown, produced into a short neck; bulbils small ovate acute, usually covered with a leathery tunic, inner surface flattened, produced at the base

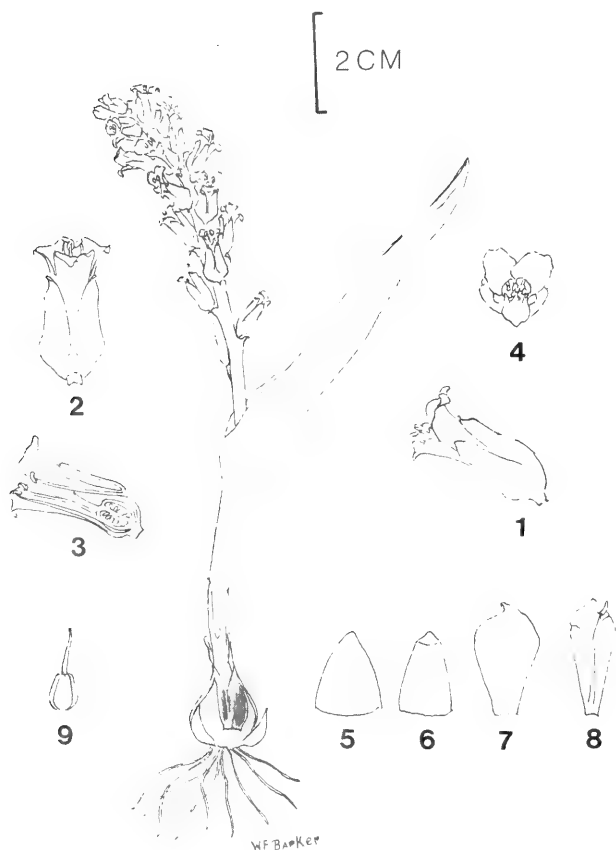


FIG. 13

Lachenalia maximiliani: 1. flower side view; 2. flower from below; 3. longitudinal section of flower; 4. flower front view; 5. lateral outer perianth segment; 6. upper outer perianth segment; 7. upper inner perianth segment; 8. lower inner perianth segment and stamen; 9. gynoecium, all $\times 3$. (Wagener 119).

of the bulb between the bulb scales. *Leaf* 1, with a loosely clasping base up to 60 mm long, widening gradually above into a lanceolate, canaliculate, yellow-green blade, 30–90 mm long and 10–30 mm broad at base, suberect to spreading. *Peduncle* slender, up to 60 mm long. *Inflorescence* few to many-flowered, up to 100 mm long and 20 mm diam., subspicate, lower flowers usually sessile, upper with a very short pedicel, suberect to spreading. *Perianth* narrow urceolate, 7–9 mm long; tube 2 mm long, very pale blue; outer segments 6 mm long, 4 mm broad, ovate, very pale blue at base, white above with reddish-brown gibbositities; inner segments 7–8 mm long, obovate oblong, subacute, white with bluish-green keels, apices recurved, lowest narrower and slightly more spreading; stamens shorter, to as long as inner segments; ovary ovate, 2 mm long; style 3–4 mm long, finally as long as stamens. *Capsule* ovate, membranous, 6 mm long; seed globose, aril ridged terminal, short.

DIAGNOSTIC CHARACTERS

Lachenalia maximiliani most closely resembles *L. fistulosa*, but differs from it in having a single plain yellow-green lanceolate, canaliculate leaf. Its compressed bulbils are produced between leathery bulb scales, and they are usually enclosed in a leathery sheath. The seeds have a ridged aril, while the aril in *L. fistulosa* is inflated.



FIG. 14

Lachenalia maximiliani: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3219 (Wuppertal): Wuppertal (-AC), 20/8/1959, *Barker* 8993 (NBG, hol.).

This dainty dwarf species was first collected by Rudolph Schlechter in August 1896, and was widely distributed by him under his manuscript name *Lachenalia maximiliani*. It usually grows on steep mountain slopes, and though somewhat inconspicuous in the field, when grown in mass it makes a charming, tidy pot plant.

SPECIMENS EXAMINED

CAPE PROVINCE—(Wuppertal): Wuppertal (-AA), 20/8/1959, *Barker* 8993 (NBG); Koudeberg near Wuppertal, 28/8/1896, *Schlechter* 8725 (BM, G, GRA,

K, L, PRE, S, Z); Pass above Wuppertal, 28/8/1951, *Martin 802* (NBG); Middelpaas, Bidouw Valley, 8/7/1941, *Leipoldt s.n.* sub. NBG 72245 (NBG); Mertenhof Farm, Bidouw Valley, 15/8/1974, *Wisura 2873* (NBG); Matjesrivier, Cedarberg, (-AD), 19/8/1943, *Wagener 119* (NBG).

***Lachenalia polypodantha* Schltr. ex Barker, sp. nov.**

Distinguitur folio unico patente ovato supra pilis stellatis vestita, basi amplectenti, pedunculo brevissimo, inflorescentia densa racemosa, floribus parvis, pedicellis longis, periantho late campanulato albo, staminibus exsertis, filamentis purpureis, seminibus ovatis acutis, testa rugosa jugis irregularibus, arillo acuto jugoso breve.

Plant up to 150 mm high. *Bulb* globose up to 15 mm diam.; outer tunics membranous, light russet. *Leaf* 1, up to 80 mm long; blade ovate up to 40 mm long, 20 mm broad, spreading, upper surface densely covered with stellate hairs; clasping base up to 50 mm long. *Peduncle* very short, 10–20 mm long above the clasping base of leaf. *Inflorescence* racemose many-flowered, up to 70 mm long,

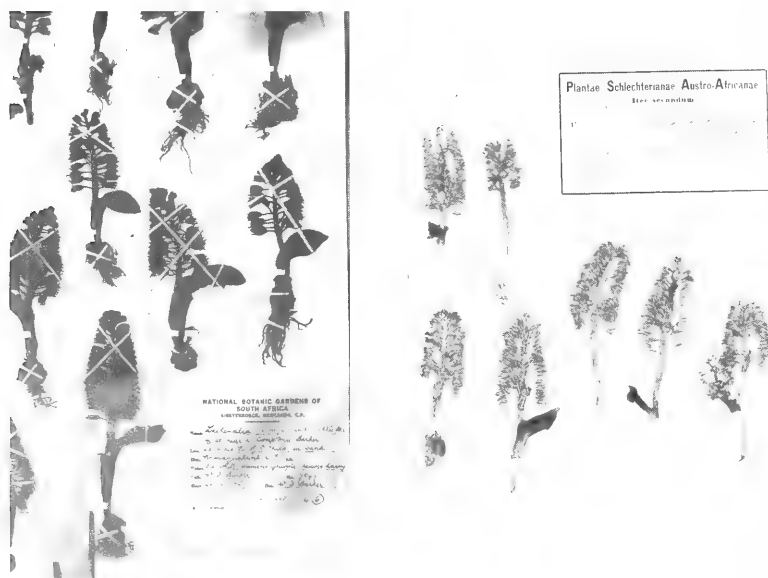


FIG. 15 a,b

Lachenalia polypodantha: a. portion of type sheet in Compton Herbarium (*Barker 9049*); b. portion of sheet in Herbarium, Royal Botanic Gardens, Kew. (*Schlechter 11384*).

30 mm diam.; pedicels spreading at right angles, 5–9 mm long, becoming shorter toward the apex of the scape. *Bracts* very small, membranous. *Perianth* widely campanulate, white, up to 7 mm long; tube 2 mm long, narrowing at the base; outer segments ovate, 4 mm long, 2.5 mm broad, obtuse, white with pale green gibbosities; inner segments 2 mm longer than outer, emarginate, white with pale green spot near apex; stamens well exserted beyond the inner segments; filaments purple; ovary obovate 3 mm long; style finally exserted beyond the stamens. *Capsule* obovate, membranous; seed very small ovate acute, the testa wrinkled into an irregular pattern of ridges; aril ridged, terminal, small.

DIAGNOSTIC CHARACTERS

Lachenalia polypodantha is a dwarf species, with a single ovate leaf densely covered with stellate hairs on the upper surface. The inflorescence is many-flowered, the pedicels spreading at right angles, becoming shorter toward the apex. The flowers are white, widely campanulate and the purple filaments are well exserted. It belongs to the small group with very small seeds, with the testa wrinkled into an irregular pattern of ridges.

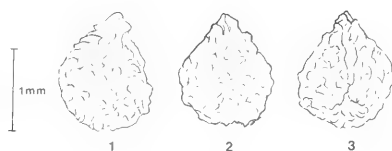


FIG. 16

Lachenalia polypodantha: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—2917 (Springbok): 25 m N of O'okiep (-DB), 25/8/1959, *Barker 9049* (NBG, holo.).

Only two collections of this dainty species have been recorded, both from northern Namaqualand near Springbok. Schlechter's specimens which he distributed under his manuscript name, were collected in the fruiting stage, fortunately the second collection was found in peak condition, which made identification possible. At first sight the plant is reminiscent of *L. comptonii*, both having white flowers with purple exserted stamens, and a leaf covered on the upper surface with many stellate hairs, but while in *L. comptonii* the flowers have very short pedicels, and seeds have a smooth shining surface and a short ridged aril, *L. polypodantha* has long pedicels spreading at right angles, and the seeds have a testa wrinkled all over in an irregular pattern of ridges.

They are also well separated geographically, as *L. comptonii* occurs in the inland Karoo areas from Worcester, Ceres, Laingsburg, Sutherland to Calvinia, while *L. polypodantha* is only known from Springbok in Namaqualand. Both occur in sandy areas.

SPECIMENS EXAMINED

CAPE PROVINCE—2917 (Springbok): Karoechas (-BB), 25/9/1896, Schlechter 11384 (B, BM, GRA, K, LD, PRE, Z); 25 m N of O'okiep (-DB), 25/8/1959, Barker 9049 (NBG).

Lachenalia stayneri Barker, sp. nov.

Distinguitur foliis 2 ovato-lanceolatis vel loratis prostratis supra pustulis magnis dispersis ornatis, pedunculo gracili, inflorescentia laxa racemosa, floribus leviter cernuis, periantho campanulato, basi truncato, segmentibus internis externis paulo longioribus, staminibus valde exsertis, seminibus globosis, arillo inflato terminate mensure medio.

Plant 120–300 mm high. *Bulb* globose 15–30 mm diam., with dark brown spongy tunics. *Leaves* 2, usually ovate-lanceolate, occasionally lorate, with a short clasping base, blade prostrate, 40–150 mm long, 15–30 mm broad, green with large scattered wart-like pustules above, sometimes tinged with maroon, lower side tinged with maroon. *Peduncle* 40–130 mm long, slender, spotted or mottled with maroon. *Inflorescence* racemose, scape spotted or tinged maroon, flowers many, lax, spreading to slightly cernuous; bracts narrow lanceolate acute, membranous, white or tinged with maroon; pedicels 2–7 mm long spreading. *Perianth* 5–8 mm long, 4–5 mm diam., campanulate; tube up to 2 mm long, very pale blue; outer segments 5–7 mm long, obovate, erect, cream with red-brown gibbositities; inner segments narrow oblong slightly longer than the outer, cream with red-brown spot near apex; stamens well exserted, up to 11 mm long declinate; ovary globose, 2–3 mm diam., green; style up to 8 mm long. *Capsule* globose 6 mm diam., membranous; seed globose, aril inflated, terminal, medium length.

DIAGNOSTIC CHARACTERS

Lachenalia stayneri is most closely allied to *L. latifolia* Tratt., in having two ovate-lanceolate prostrate leaves usually pustulate above, and flowers with well-exserted stamens, but in *L. stayneri* the inflorescence is much more lax and wider with longer pedicels, while the flowers are larger, truncate at the base, the inner segments erect and the stamens declinate. Their seeds both fall into the group with inflated, terminal arils.

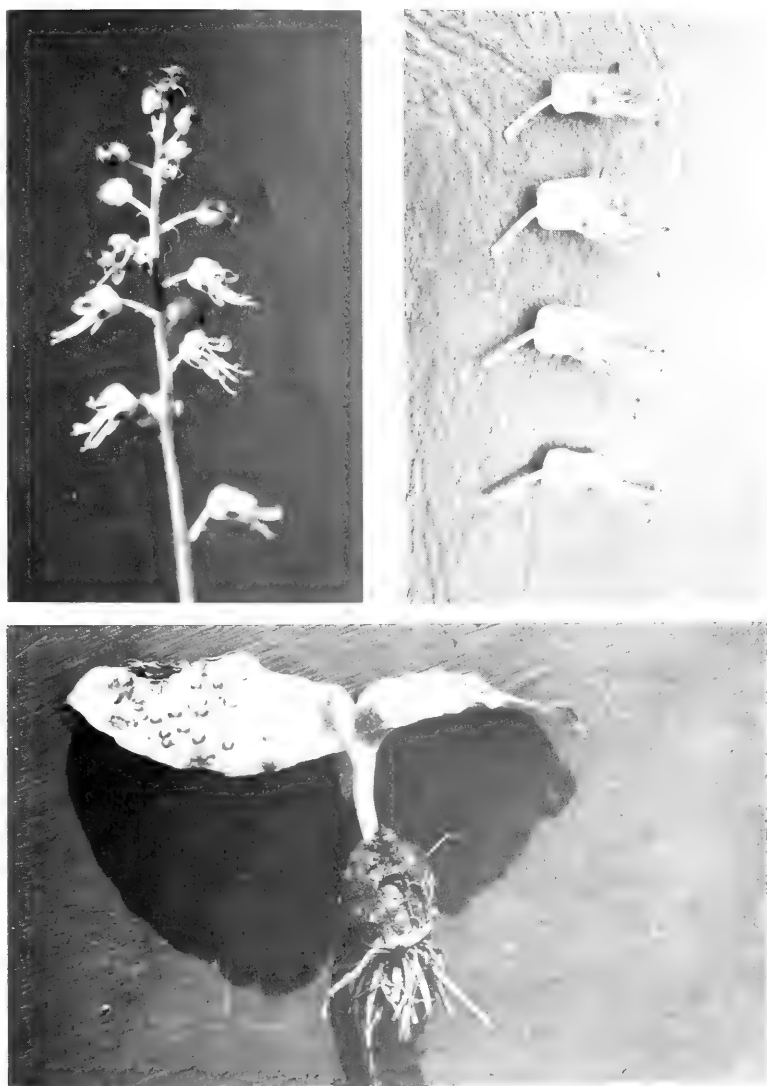


FIG. 17 a,b,c
Lachenalia stayneri: a. inflorescence; b. flowers; c. bulb in leaf. (Stayner s.n. sub NBG 88509).

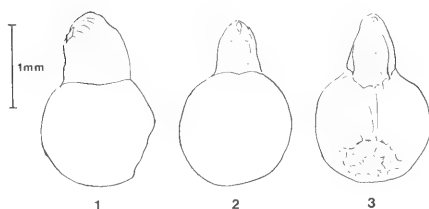


FIG. 18

Lachenalia stayneri: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3319 (Worcester): De Wet N. of Worcester (-DA), 14/8/1972, *Stayner s.n.* sub. NBG 88509 (NBG, holo.); 1/9/1971, *Stayner s.n.* sub. NBG 88509 (NBG, iso.).

The earliest record of this distinctive species, with its prostrate, pustulate leaves, was made in the Worcester Karoo Botanic Garden on 3rd September, 1947. It has since been found at De Wet and in several other localities in the Worcester district, and also near Robertson. It has been named in honour of Mr F. J. Stayner, who was Curator of the Worcester Karoo Botanic Garden for many years, and provided the Compton Herbarium with numerous interesting plants, collected on his botanical expeditions.

SPECIMENS EXAMINED

CAPE PROVINCE—3319 (Worcester): Worcester Karoo Botanic Garden (-CB), 3/9/1947, *Barker 4638* (NBG); 20/8/1953, *Compton 24119* (NBG); Veld reserve, Worcester, 28/8/1962, *M. C. Olivier 52* (NBG, UNIV STEL); De Wet N of Worcester (-DA), 11/8/1969, *Stayner s.n.* sub. NBG 88590 (NBG); 7/9/1969, *Stayner s.n.* sub. NBG 93576 (NBG, iso.); 14/8/1972, *Stayner s.n.* sub. 93908 (NBG, holo.); 1/9/1971, *Stayner s.n.* sub. NBG 93908 (NBG, iso.); 23/9/1974, *Oliver 5035* (PRE); Kweekskraal, Hex River, 8/9/1962, *Hall 2575* (NBG); Robertson (-DD), 17/9/1968, *Loubser 2121* (NBG); 31/8/1973, *Loubser 2121* (NBG).

Lachenalia ventricosa Schltr. ex Barker, sp. nov.

Distinguitur folio unico lanceolato vel lorato canaliculato viride-flavo margine undulato, basi laxae amplexcenti, pedunculo infra inflorescentiam plerumque inflato, inflorescentia spicata, floribus magnis patentibus, periantho anguste urceolato basi pallide caeruleo, segmentibus externis longioribus, pallide flavis prope apicem zona viridi, staminibus valde exsertis, seminibus globosis, arilla inflato terminale longo.

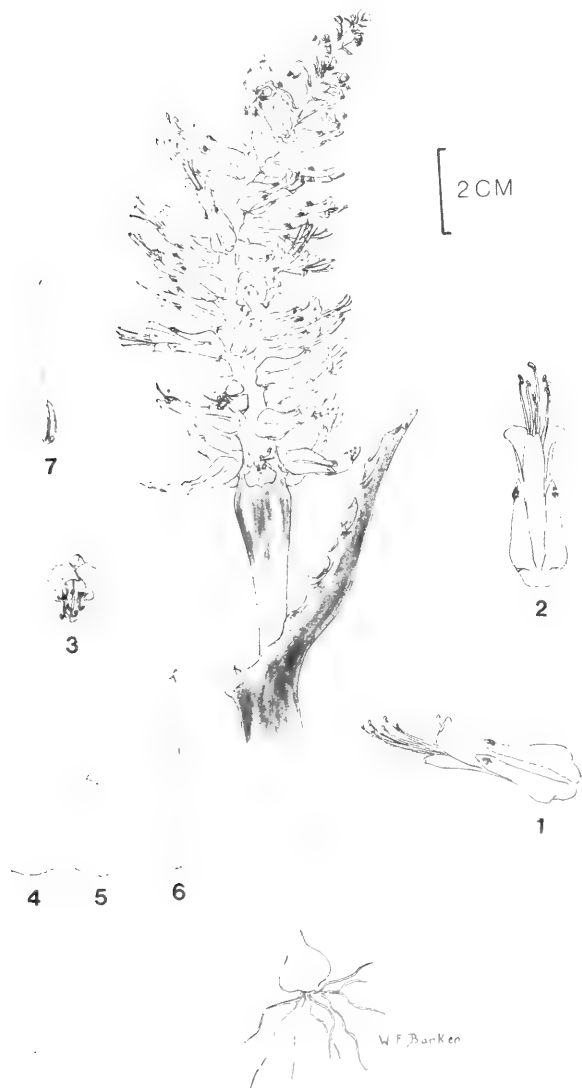


FIG. 19

Lachenalia ventricosa: 1. flower side view; 2. flower from below; 3. flower front view; 4. lateral outer perianth segment; 5. upper outer perianth segment, 6. lateral inner perianth segment and stamen; 7. gynoecium, all $\times 2$. (Salter 3615).

Plant 200–480 mm high. *Bulb* globose 15–20 mm diam.; outer tunics membranous, light brown. *Leaf* 1, very occasionally 2, 190–380 mm long; blade erect to spreading, 130–260 mm long, up to 30 mm wide, lanceolate acute to lorate, canaliculate, bright yellow-green, margin usually undulate; clasping base 60–120 mm long, widening above to 15 mm diam., forming a loose sheath, whitish below shading to light purple above. *Peduncle* usually short, inflated below the inflorescence, green or suffused with red-brown, 30–140 mm long, up to 13 mm diam. below the inflorescence. *Inflorescence* spicate, 80–200 mm long, 30–40 mm diam.; flowers many, spreading; rachis inflated at base, narrowing upwards, often to a long sterile apex with many vestigial flowers, subtended by narrow lanceolate bracts. *Perianth* 12–18 mm long, narrow with an urceolate base; tube 2.5 mm long, very pale blue; outer segments up to 9 mm long, ovate, white tinged with very pale blue at base, with green to brown gibbositities; inner segments up to 15 mm long, distinctly longer than the outer, obovate, oblong, pale yellow shading to white at margin with a green zone near the apex, apex slightly spreading; stamens exserted; filaments 15–23 mm long, white; ovary oblong green, 3 mm long; style 15–17 mm long. *Capsule* oblong 8 mm long, 5 mm diam., membranous; seed globose; aril inflated, terminal, long.

DIAGNOSTIC CHARACTERS

Lachenalia ventricosa is characterised by having a single lanceolate to lorate canaliculate leaf. Its peduncle is inflated, its spicate inflorescence usually has a long sterile apex, and the large sessile, narrow urceolate flowers have well-exserted stamens and style. The seed has a long, inflated, terminal aril, similar to that of *L. orchiioides*, with which it has an affinity.

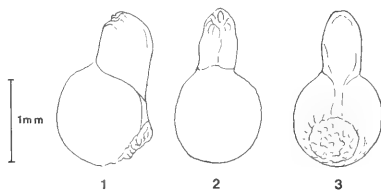


FIG. 20

Lachenalia ventricosa: 1. seed side view; 2. seed from above; 3. seed from below.

Type Material: CAPE PROVINCE—3118 (Vanrhynsdorp): Nardouw Mts (-DD), 6/9/1933, Salter 3615 (BOL, holo.; K, iso.).

The earliest collections of this species were made by Rudolph Schlechter on 3rd September, 1896, at Langkloof N.W. of Clanwilliam and on 7th September, 1897 at Brandewynrivier between the Pakhuis Pass and Doornrivier, and sets of

these collections were distributed to many herbaria under his manuscript name, which presumably refers to the swollen peduncle.

The type specimens were collected by Miss Hermione Nortier on the Nardouw plateau on 6th September, 1933 and were brought in by Paymaster Captain T. M. Salter. The accompanying figure was made from one of these wild specimens. Collections have been made in this area a number of times since, and the flowers have been consistently larger and the plants more robust than those of the Schlechter specimens.

SPECIMENS EXAMINED

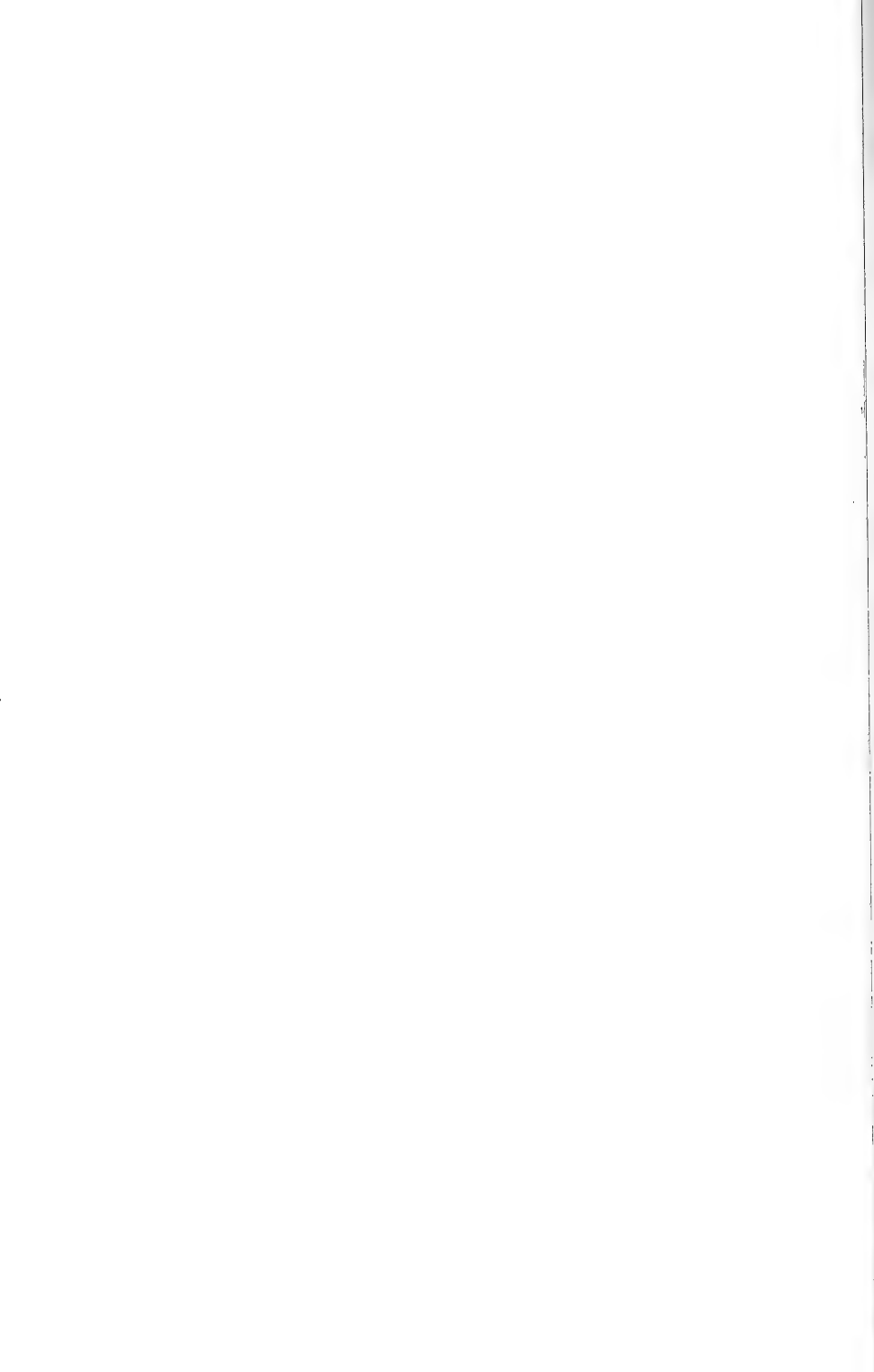
CAPE PROVINCE—3118 (Vanrhynsdorp): Nardouw Mts (-DD), 6/9/1933, *Salter 3615* (BOL, holo.; K, iso.); Nardouw Pass, Sept 1947, *Lewis 2432* (SAM); Near Nardouw Pass, Sept 1945, *Lewis 1238* (SAM); Nardouw, 14/9/1947, *Barker 4746* (NBG); Nardouw, Sept. 1951, *Barker 7439* (NBG); Nardouwberg Plateau bet. Vondeling and Syferkop, 13/8/1963, *Rourke s.n.* sub. NBG 93578 (NBG); 15 m S. of Doorn River Bridge, 25/8/1950, *Barker 6564* (NBG); Lange Kloof, 3/8/1986, *Schlechter 8398* (B, BM, BOL, G, GRA, K, PRE, Z).
—3219 (Wuppertal): Brandewynrivier (-AA), 13/8/1896, *Schlechter 10827* (BM, BOL, G, GRA, K, L, LD, PRE, S, Z).

ACKNOWLEDGEMENTS

In the preparation of this paper, special thanks is due to Professor E. A. Schelpe for preparing the Latin translations.

I wish to express my thanks to all the curators of the herbaria mentioned, who have provided me with facilities or sent specimens on loan, also to the Photographic Department of the Jagger Library for the photographs of the paintings, and to the Kew Herbarium for the use of the photograph of the herbarium sheet.

My grateful thanks to all collectors and particularly to Mrs M. Thomas, Miss B. E. Martin, Dr M. Courtenay-Latimer, Mr F. J. Stayner, Mr H. Hall and Col R. Bayliss, and my sincere appreciation to the Macgregor family, and to Mr and Mrs Neil Macgregor in particular, for their generosity and co-operation over many years.



A NEW NAME FOR *BLECHNUM CAPENSE* (L.) SCHLECHTEND.

E.A.C.L.E. SCHELPE

(*Bolus Herbarium, University of Cape Town*)

ABSTRACT

Blechnum capense (L.) Schlechtend. (1825) is antedated by *Blechnum capense* Burm.f. (1768). *Blechnum sylvaticum* Schelpe is proposed as a new name for the former.

UITTREKSEL

'N NUWE NAAM VIR *BLECHNUM CAPENSE* (L.) SCHLECHTEND.

Blechnum capense Burm.f. (1768) is ouer as *Blechnum capense* (L.) Schlechtend. (1825). *Blechnum sylvaticum* Schelpe word voorgestel as 'n nuwe naam vir laasgenoemde.

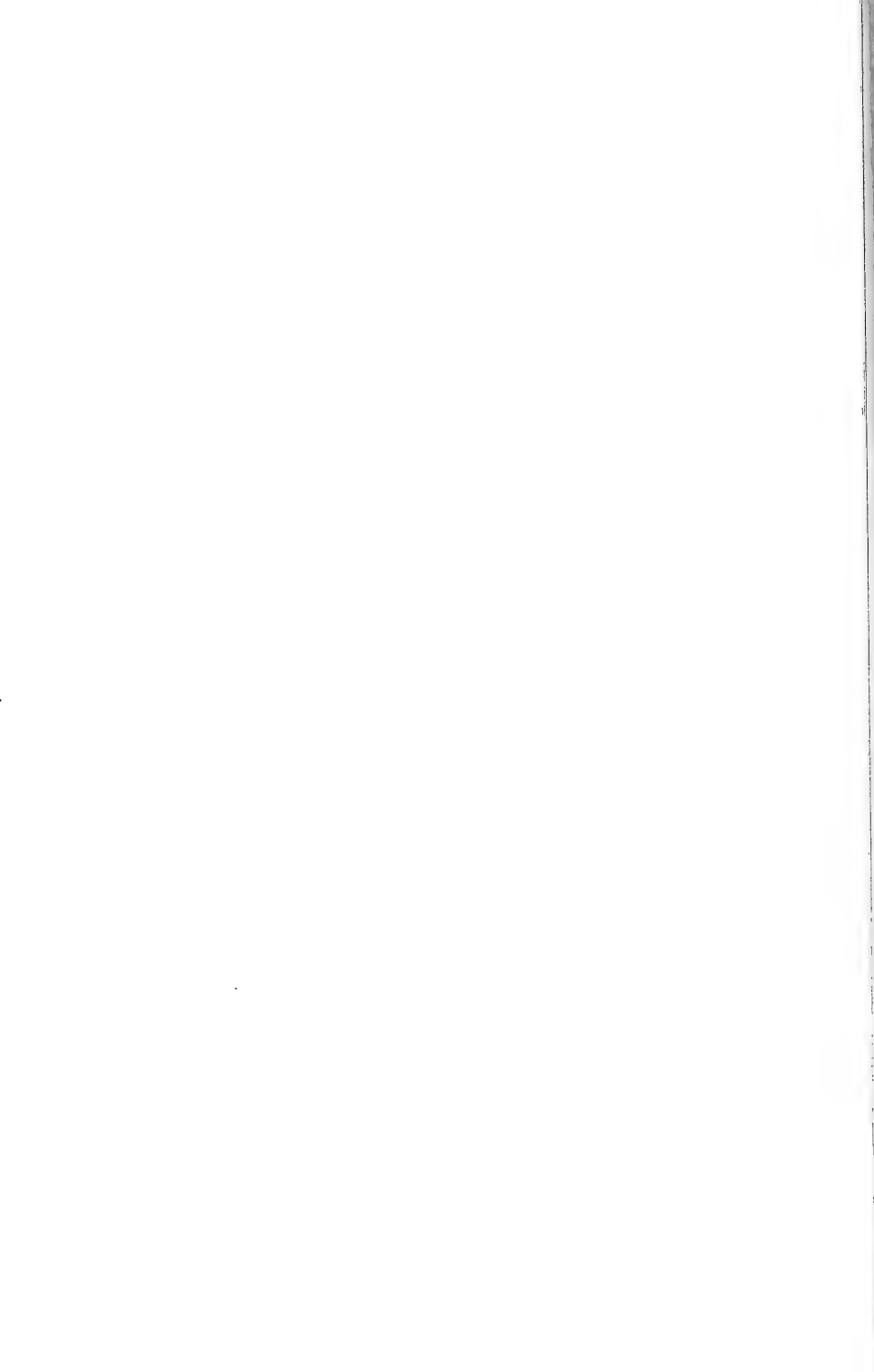
In the *Index Filicum*, Christensen (1906) accepted the name *Blechnum capense* (L.) Schlechtend. based on *Osmunda capensis* L., which is typified by a Koenig collection from between Table Mountain and Devils Peak on the Cape Peninsula (LINN 1244/11). This view has remained unquestioned. However the use of the name was antedated by *Blechnum capense* Burm.f. (in the *Florae Capensis Prodrum* [1768]) despite Christensen's dismissal of it as a "nomen". The younger Burman's description of it is as follows:

BLECHNUM (capense) frondibus pinnatis, pinnis sessilibus cordato-lanceolatis integerrimis.

Although this description is meagre, the younger Burman's *B. capense* is validly published. On a short visit to Geneva some years ago I was unable to locate a holotype, but Mr H. P. Linder has recently returned from Geneva with photographs of a specimen annotated by Houttyn:

"*Blechnum capense* appellavit N. L. Burmannus . . ." which could be used as evidence of the younger Burman's concept of his species. The sheet is a mixture of two species currently known as *Blechnum australe* L. and *B. punctulatum* Sw. The younger Burman's description applies equally well to both elements. It therefore appears that the name *Blechnum capense* Burm.f. is based on two discordant elements and should be rejected. The prior use of the name *Blechnum capense* by the younger Burman precludes its use as *Blechnum capense* (L.) Schlechtend.

Consequently, I propose *Blechnum sylvaticum* Schelpe as a nomen novum for *Blechnum capense* (L.) Schlechtend. (1825) non *Blechnum capense* Burm.f. (1768).



A NEW SPECIES OF *TAPINANTHUS* (LORANTHACEAE)

H. R. TÖLKEN

(Botanical Research Institute, Pretoria)

D. WIENS

(Department of Biology, University of Utah, Salt Lake City, U.S.A.)

ABSTRACT

An evaluation of the nomenclature of *Tapinanthus minor* revealed that this name has been misapplied to a species which is here described as *T. gracilis* Toelken & Wiens.

UITTREKSEL

'N NUWE *TAPINANTHUS* SOORT (LORANTHACEAE)

'n Hersiening van die nomenklatuur van *Tapinanthus minor* het gewys dat dié naam verkeerdelik gebruik is vir 'n spesie wat hier as *T. gracilis* Toelken & Wiens beskryf word.

Since Harvey (1862) described *Loranthus zeyheri* var. *minor* there has been uncertainty about the identity of the variety. In the description Harvey stated that the flowers of *L. zeyheri* resembled those of *L. natalitius*, and this may be the reason why Wood (1907) transferred var. *minor* to *L. natalitius*. Sprague (1915) explained that he considered var. *minor* erroneously placed under *L. zeyheri* and followed Wood in citing it as *L. natalitius* var. *minor* in the synonymy of *L. minor*.

Sprague did not quote the type specimen of *L. minor* among the material investigated, and it seems that he had not seen it as he cited only specimens from the Natal coast. The specimen *Gerrard 1434* (K) which is annotated '*L. natalitius* var. *minor*' in an undetermined hand is probably the origin of all the confusion as it must be identified as the species now described. This specimen was incorporated in Kew herbarium in 1865 and according to the archives at Kew could have been one of many other Gerrard specimens received from Harvey.

Var. *minor*, as interpreted by Wood (1907), and *L. minor*, as used by Sprague (1915), refer to this slender plant from the lowland mountains of the south-east Transvaal, Swaziland and Natal coast. Neither Burke nor Zeyher ever collected anywhere near those areas.

The original var. *minor* was based on a depauperate specimen of *L. zeyheri* mounted together with a larger specimen of *Zeyher 751*. As Harvey annotated the

depauperate specimen (751a) separately "omnino *L. Zeyheri*, sed foliis floribusque minoribus. *L. Zeyheri* minor" there is no need to select a lectotype.

The taxonomy of this complex is therefore recast as follows:

1. *Tapinanthus natalitius* (Meisn.) Danser in Verh. K. Akad. Wet., sect. 2, 29, 6: 116 (1933). Type: Natal, sine loc. exact., *Krauss* 208 (K, holo.!).

1a. subsp. *natalitius*.

Loranthus natalitius Meisn. in Hooker, Lond. J. Bot. 2: 539 (1843); Harv. in Fl. Cap. 2: 576 (1862); Sprague in Fl. Cap 5, 2: 114 (1915); Ross, Fl. Natal 152 (1972); Gibson, Wild Flow. Natal, pl. 30, 1 (1974).

Acranthemum natalitium (Meisn.) v. Tieghem in Bull. Soc. bot. Fr. 42: 255 (1895).

Distinguished mainly from subsp. *zeyheri* by usually having obovate leaves which are 40–50 mm long, glabrous and glaucous. The corolla and pedicels are usually glabrous and the subspecies occurs mainly in Natal.

1b. subsp. *zeyheri* (Harv.) Wiens in Bothalia 12: 423 (1978).

Type: Transvaal, Magaliesberg, *Zeyher* 751 (K, holo.!, S! SAM!).

Loranthus zeyheri Harv. in Fl. Cap. 2: 576 (1862); Sprague in Fl. Cap. 5, 2: 113 (1915); Burt Davy, Fl. Transv. 465 (1932); Letty, Wild Flow. Transv. pl. 61, 4 (1962).

Acranthemum zeyheri (Harv.) v. Tieghem in Bull. Soc. bot. Fr. 42: 255 (1895).

Tapinanthus zeyheri (Harv.) Danser in Verh. K. Akad. Wet., sect. 2, 29, 6: 122 (1933).

L. zeyheri Harv. *minor* Harv. in Fl. Cap. 2: 576 (1862). Type: Transvaal, Magaliesberg, *Zeyher* 571a (S, holo.!).

Tapinanthus minor (Harv.) Danser in Verh. K. Akad. Wet., sect. 2, 29, 6: 116 (1933).

L. moorei Sprague in Kew Bull. 1915: 70, 80 (1915); in Fl. Cap. 5, 2: 114 (1915); Burt Davy, Fl. Transv. 465 (1932).

Tapinanthus moorei (Sprague) Danser in Verh. K. Akad. Wet., sect. 2, 29, 6: 116 (1933). Type: Transvaal, near Barberton, *Moore s.n.* (K, holo.!).

The leaves of this subspecies are mostly oblanceolate to obovate, 20–30 mm long, mostly puberulent to pubescent. The corolla is puberulent to hirsute; pedicels puberulent to pubescent. This subspecies occurs mainly in the Transvaal.

2. *Tapinanthus gracilis* Toelken & Wiens, sp. nov. a *T. natalitio* foliis prasinis parvis (13–45 X 5–15 mm) et floribus gracilioribus differt.

Loranthus natalitius Meisn. var. *minor* (Harv.) Wood, Handb. Natal Pl. 115 (1907), pro parte typo excl.

L. minor (Harv.) Sprague in Kew Bull. 1915: 80 (1915), pro parte; in Fl. Cap. 5, 2: 115 (1915), pro parte quoad spec. enum.

Fruticuli ramis gracilibus usque ad 0,5 m longis, glabri. *Folia* sub-opposita rare spiralia, petiolata vel subsessilia; lamina elliptica vel oblongo-oblancheolata, rare obovata, (13-) 20-35 (-45) X 5-10 (-15) mm, cuneata, plerumque acuta, venis tribus a base, aliquantum coriacea, prasina; petiolus 0-3 (-5) mm longus. *Inflorescentia* umbella (1) 2-6 floribus ramorum brevium lateralium ad apicem, glabra; pedicelli (3-) 5-10 mm longi. *Calyx* cupulatus et sine lobis, c. 1,5 mm longus. *Corolla* glabra; tubus cylindricus, gracilis, 30-40 mm longus, leviter tumidus ad basim, plus minusve penitus fissus, pallide roseus; lobi partim connati vel discreti, 10-12 (-15) mm longi, olivacei lutei et sanguinei fasciati circum antheras. *Anthera* 6-8 mm longa. *Baccae* obovoideae vel paene sphaericae, 8-10 mm longae, rubrae.

Type: Natal, 12 km N. of Josini, Tölken & Germishuizen 5797 (PRE, holo.!).

Shrublets with slender branches up to 0,5 m long, glabrous. *Leaves* sub-opposite rarely spirally arranged, petiolate to subsessile; blade elliptic to oblong-oblancheolate, rarely obovate, (13-) 20-35 (-45) X 5-10 (-15) mm, cuneate, usually bluntly acute, with three major veins from the base, somewhat leathery, dark green; petiole 0-3 (-5) mm long. *Inflorescence* umbellate with (1) 2-6 flowers at the apex of spur-branches, glabrous; pedicels (3-) 5-10 mm long. *Calyx* cup-shaped and without lobes, c. 1,5 mm long. *Corolla* glabrous; tube cylindrical, 30-40 mm long, slender, slightly swollen at the base, more or less deeply split, pale pink; lobes partly fused to completely free, 10-12 (-15) mm long, olive green with a band of yellow and deep red around the anthers. *Anthers* 6-8 mm long. *Berries* obovoid to almost spherical, 8-10 mm long, red.

Parasitic on a large number of hosts including species of *Acacia*, *Acalypha*, *Berchemia*, *Dombeya*, *Ehretia*, *Grewia*, *Maytenus*, *Olea*, *Plumbago*, *Tarchonanthus*, *Viscum* and *Zanthoxylum*. Recorded from frost-free areas in the south-eastern Transvaal, Swaziland and through the coastal areas of Natal to the southern parts of this province.

BOOK REVIEWS

GRASSLAND SIMULATION MODEL, Ecological Studies 26, edited by G. S. Innes with pp. 298 + xxvi, 87 figures and 44 tables. Berlin-Heidelberg-New York, Springer Verlag, 1978. DM 49,60.

This book is bound with a hard cover of convenient size (165 × 240 mm). The text appears to have been typed and reproduced photographically on a good quality white glossy paper and is clear and easy to read. Different type sizes have been employed without creating an imbalanced effect. Italics have been used for the scientific names and mathematical formulae.

Except for the occasional use of abbreviations in the text such as mo. and yr. instead of month and year there is little fault to be found with the accuracy of the text. The term bar instead of kPa as a unit for waterpotential has also been used.

A list of contributors responsible for the text is given in the preliminary pages of the book. Each chapter contains an abstract, introduction, conclusion and discussion, acknowledgements and a list of references. In the first chapter a clear view of the objectives and structure for a grassland simulation model is given. Each chapter deals with a subsection of an ecosystem and the results are used to compose a grassland ecosystem model.

The global objective of this research and modelling activity was to develop a total system model of the biomass dynamics of a grassland, representative of grassland in the United States of America. This book gives a clear indication of the extent and problems of such a modelling activity. In the last chapter a critical evaluation and analysis of the grassland ecosystem model is given.

The model presented combines hypotheses in a manner that facilitates comparison of results to data and thereby tests the hypotheses. Areas where knowledge about the ecosystem is inadequate are identified and can be investigated experimentally.

There is an abundance of illustrative material. The drawings are well done and clear, as are the diagrams. The photographs are chosen to give an idea of the research sites, but are unfortunately too dark to give a clear indication of the vegetation and the research site as a whole.

There are enough references in the text and those given are to the point under discussion. There is a comprehensive list of references at the end of each chapter which is extremely useful to the reader.

The index is comprehensive and detailed and a subject and author index is given at the back of the book.

The book is aimed primarily at teachers of ecosystem ecology, but would be very useful for postgraduate students. It is not suitable for the unaided undergraduate student. The research worker will find much in it, as well as pasture science research workers and extension officers dealing with farm planning and management.

The information given in this book could be applicable to South African conditions.

The book is not a textbook in the normally accepted sense. It is intended to give a review of the facts and problems about a grassland ecosystem model and research to be done to put forward such a grassland simulation model.

Despite minor shortcomings it is a highly interesting book and recommended to ecologists.

W. L. J. VAN RENSBURG

INCOMPATIBILITY IN ANGIOSPERMS, by D. de Nettancourt, with pp. xiii, 230 + 45 figures and 18 tables. ISBN 3-540-08112-7. Berlin, Heidelberg, New York: Springer-Verlag, 1977. Volume 3 in the series "Monographs on Theoretical and Applied Genetics", co-ordinating editor R. Frankel. Cloth DM 56, US\$ 24.70.

One might be excused for expecting a book with the title *Incompatibility in Angiosperms* to be a rather dry reference book destined to gather dust on a top shelf. Quite the contrary. This third in the series on Theoretical and Applied Genetics proved to be a very readable and attractive presentation of a complex subject.

The need for discrimination between self and non-self is very basic to living organisms of all types. The restriction enzymes of bacteria, that are proving so useful to molecular biologists, probably evolved to meet this need as did the very involved immune systems and many complex behavioural mating patterns of higher animals. Such recognition systems serve as the first step in the defence against invasion by parasites as well as assuring that fertilization occurs only between gametes of the same or very similar species.

Many higher plants have also evolved systems which seem to work in the reverse direction, preventing self-fertilization. It is the genetic systems involved in the inherited ability of a flower to reject its own pollen that forms the subject of this book.

The field covered is a very extensive one extending over more than 200 years and the author is to be congratulated for organising the material into a very readable whole. The basic features of self-incompatibility are discussed in chapter one. Further chapters consider the genetic basis of self-incompatibility, morphology and biochemistry of the self-incompatibility reaction, modifications and mutation of the systems, interspecific incompatibility and finally a most stimulating chapter on incompatibility in basic and applied researches. The book should be of interest to Botanists, Plant Breeders, Evolutionists, Geneticists and Plant Biochemists. It is well indexed and the References contain over 500 entries.

The history of the study of the phenomenon of self-incompatibility reflects general development in biology as a whole—first observation and description, followed in this century by recognition of genetic control and study of the inheritance patterns involved. Biochemical studies and such techniques as electron microscopy followed and finally the most sophisticated techniques of modern molecular biology are being brought to bear on the study. The excitement of the pursuit of understanding of complex phenomena is well captured in this monograph.

NANCY VAN SCHAIK

THE BIOLOGY OF LICHENS, by Mason E. Hale, with pp. viii, 181 + 134 illustrations. 2nd edition. London: Edward Arnold, 1974. Contemporary Biology series. £5.50 (hard cover), £2.75 (paper back).

The first edition of this book (1967) was hailed by one of the most competent reviewers with the words: "This is a good book." Of the second edition one could say: This is an improvement of a good book! There are several changes in the text which take into account recent literature and bring the book up to date. The number of pages of text is the same, there is an increase of 3 pages in the bibliography and index which is set in a clearer type. The reference numbers have not been changed but new references are indicated by letters after the number. This is (for a textbook) a commendable practice. A number of illustrations have been replaced by clearer ones and the printing of some of the half-tone illustrations seems to be better than in the first edition. But the character of the book has not changed, it is an excellent introduction to the Lichens for the general botanist and especially valuable for ecologists and non-specialist students of the environment.

Lichens form an extremely interesting group of organisms that can be studied from numerous angles. On the other hand the study of Lichens has contributed to other fields such as physiology (symbiosis), phytochemistry and ecology. I feel that Lichens are still

rather neglected in the training of botanists so that very few people really know much about Lichens, and hardly see them in the field. The fact that Lichen taxonomy is very difficult (are there really as many as 15 000 "species"?), and that there are too few Lichen specialists in the world (no one, as far as I know, in South Africa) may have contributed to this situation. But in order to appreciate the importance of Lichens in nature and in science, a general knowledge of some of the more conspicuous forms should be helpful and could lead to increased interest. Hale's book should be an excellent guide. I consider it the most important basic text in English.

W. J. LÜTJEHARMS

ANNOUNCEMENT

FASCICLES OF FLORA OF INDIA

The Botanical Survey of India announces publication of the first Fascicle of Flora of India. Copies are obtainable from the office of The Director, Botanical Survey of India, P.O. Botanic Garden, Howrah - 711103, India.

EFFECT OF VARYING CARBOHYDRATE LEVELS ON THE UPTAKE AND TRANSLOCATION OF ^{32}P IN *ERAGROSTIS CURVULA* (SCHRAD.) NEES

G. NAIDOO AND T. D. STEINKE

(Department of Botany, University of Durban-Westville)

ABSTRACT

The uptake and subsequent translocation of ^{32}P among root, crown and leaf tissues of *Eragrostis curvula* were investigated in plants with varying carbohydrate levels. Plants were depleted of carbohydrates by being subjected to 3 days of continuous darkness and by defoliation. Plant roots were introduced to nutrient solutions containing ^{32}P , at 0, 3, 6, 9, 12, 15 and 21 days after the depletion treatments. Initially, plants depleted of carbohydrates absorbed and translocated less ^{32}P than the controls. Subsequently, uptake and translocation increased probably to restore the pools of phosphate to levels prior to the depletion treatments. Increased ^{32}P uptake and translocation were related to an adequate supply of reserve carbohydrates.

UITTREKSEL

DIE UITWERKING VAN WISSELENDE KOOLHIDRAATGEHALTE OP DIE OPNAME EN TRANSLOKASIE VAN ^{32}P IN *ERAGROSTIS CURVULA* (SCHRAD.) NEES

Die opname en daaropvolgende translokasie van ^{32}P in wortel-, kroon- en blaarweefsels van *Eragrostis curvula* is ondersoek by plante met verskillende koolhidraatgehalte. Die plante se koolhidrate is uitgeput deur ontblaring en blootstelling aan donkerte vir drie dae. Plantwortels is vir 0, 3, 6, 9, 12, 15 en 21 dae na die uitputtings-behandeling in voedingsoplossings wat slegs ^{32}P bevat het, geplaas. Aanvanklik het die plante, waarvan die koolhidraatgehalte gedeeltelik uitgeput is, minder ^{32}P as die kontroleplante geabsorbeer en getranslokeer. Daarna het opname en translokasie toegeneem, waarskynlik om die fosfaatpoele aan te vul tot die vlakke voor die uitputtings-behandeling. Verhoogde ^{32}P opname en translokasie was afhanklik van 'n toereikende voorraad reserwe-koolhidrate.

INTRODUCTION

Under grazing conditions grasses are frequently subjected to stress, chiefly as a result of defoliation and drought. Studies on the phosphorus nutrition of South African grasses under stress are limited. Knowledge of the trends in phosphorus uptake would yield information on the adoption of correct cutting and grazing practices and on the timing of fertilizer applications to pastures deficient in phosphorus.

Eragrostis curvula was selected for this study chiefly because of its agronomic importance as a pasture grass in South Africa. The uptake and distribution of phosphorus in plants have been the subject of many labelling experiments using ^{32}P (Ahmad, 1963; Davis & Wareing, 1965; Loughman, 1966; Etter, 1967; Crossett, 1968). However, the effect of stress conditions on phosphorus uptake has

received little attention (Tarila, Ormrod & Adedipe, 1977). The objective of this study was to bring the plant under stress by depleting carbohydrates and to determine its effect on uptake and subsequent translocation of ^{32}P .

METHOD

Plant growth

Eragrostis curvula (cv. Ermelo) plants were grown from seed in 150 mm clay pots containing a sterilised sandy loam soil. The plants were grown in an air-conditioned glasshouse. Following emergence seedlings were thinned and kept moist by frequent watering and periodic additions of a complete nutrient solution (Hoagland & Arnon, 1950). After 3 weeks seedlings were transferred to growth tanks containing complete nutrient solution. The growth tanks were continuously aerated and the solution level maintained by adding new nutrient solution. Solutions were renewed weekly.

Carbohydrate depletion treatments

Four weeks after transfer to nutrient solutions plants were selected for uniformity, transferred to growth cabinets and subjected to one of two treatments for 3 days. In the control treatment, temperatures were maintained at 30 °C (day) and 15 °C (night), with a daylength of 12 h. In the second treatment plants were grown under the same temperature conditions as the control, but were maintained in complete darkness. At the end of the treatment period 50 % of the plants in each treatment were defoliated to a height of 30 mm above soil level. All plants were subsequently returned to control conditions and divided into four treatment groups. These were: control-uncut (C-U), control-cut (C-C), dark-uncut (D-U) and dark-cut (D-C).

The experimental design was a randomised complete block with two replications per treatment.

Labelling

Two plants from each of the four treatments were labelled with ^{32}P at 0, 3, 6, 9, 12, 15 and 21 days after completion of the carbohydrate depletion treatments. Plant roots were introduced to nutrient solutions containing ^{32}P (40 $\mu\text{C}/500\text{ ml}$) as orthophosphate for 8 h.

Total nonstructural carbohydrates (TNC)

Two plants from each of the four treatments were harvested for TNC determination on each harvest date. Plants were separated into roots and crowns, freeze-dried, weighed and ground to pass a 40 mesh screen. Carbohydrate determinations were made on 0.3 g samples according to the procedure of Smith (1969).

Radioassay

Labelled plant roots were washed in running water to remove adhering radioactive solution. The plants were divided into roots, crowns, leaves and dried at 70 °C for 20 h. The plant parts were ground to pass a 40 mesh screen and 0,5 g samples wet ashed (Jackson, 1958). Aliquots of the ashed sample were pipetted onto glass fibre discs, dried under an infra-red lamp and placed in polyethylene counting vials containing 1 ml of scintillator. The scintillator used was toluene with two fluors, PPO and POPOP. All samples were counted in a Beckman LS-100 Liquid Scintillation System. All counts were corrected for background and for radioactive decay.

Statistical analyses

Analyses of variance and F tests were applied to data obtained. When significant differences were detected treatment means were compared by Duncan's Multiple Range Test at the 5 % probability level. Correlation coefficients were calculated between TNC and total plant ^{32}P .

RESULTS AND DISCUSSION

Carbohydrate analysis

The trends in percentage TNC in the roots (Fig. 1) and in the crowns (Fig. 2) were similar. Plants grown undisturbed in the dark for 3 days showed significant decreases in percentage TNC in roots and crowns on day 0. Root TNC in intact plants maintained in darkness (D-U) declined from 1,28 % initially to 0,34 % on day 0 representing a loss of 73 % (Fig. 1). The decline in TNC in the dark was due to the utilization of carbohydrates in respiration and growth. Thereafter, root TNC increased steadily since carbohydrate production was in excess of plant requirements. After day 0 there were no significant differences in root TNC of intact plants (C-U and D-U). Effects of the dark treatment on TNC in the crowns (Fig. 2) were similar to those of the roots. In the crowns of the D-U treatment TNC declined significantly from 3,65 % initially to 0,74 % on day 0, representing a loss of 80 %.

Defoliation resulted in significant decreases in TNC in the roots (Fig. 1) and crowns (Fig. 2) of the C-C treatments on day 3. Decrease in TNC continued till day 6 for the D-C treatment and up to day 9 for the C-C treatment. In the roots of the C-C treatment, TNC decreased from 1,34 % on day 0 to a minimum of 0,5 % on day 9 representing a loss of 63 % (Fig. 1). In the crowns (Fig. 2) defoliation resulted in a 76 % loss in TNC by day 9. There were no significant differences between TNC in roots or crowns of the D-C and C-C treatments after day 0. Defoliation did not have a marked effect on TNC in roots or crowns of the D-C treatment because of the very low pre-defoliation level of carbohydrate reserves.

The decrease in TNC following defoliation was presumably due to the utilization of carbohydrate reserves in regrowth and respiration. Although May &

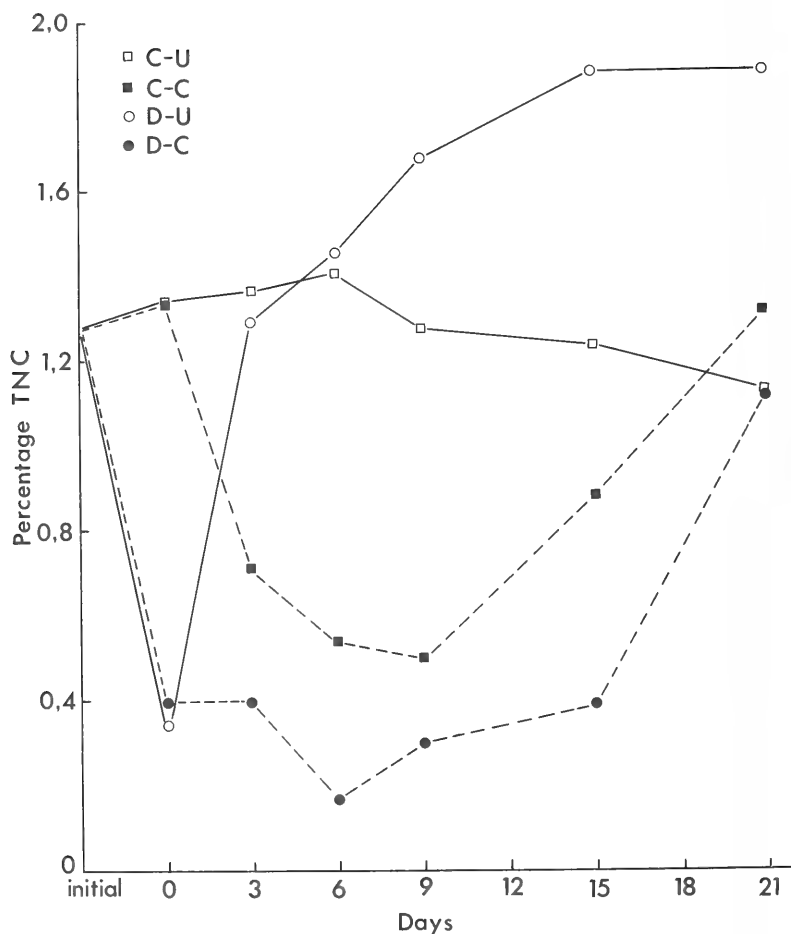


Fig.1. Changes in mean percentage TNC in the roots following treatments

Davidson (1958) queried the role of reserves in regrowth, results of several workers (Alberda, 1966; Steinke & Booysen, 1968; Steinke 1969) suggest that initial regrowth is dependent to a large extent upon an adequate supply of reserve carbohydrates. Percentage TNC in roots and crowns of defoliated plants continued to decrease as long as the production of photosynthetic assimilates fell short of the

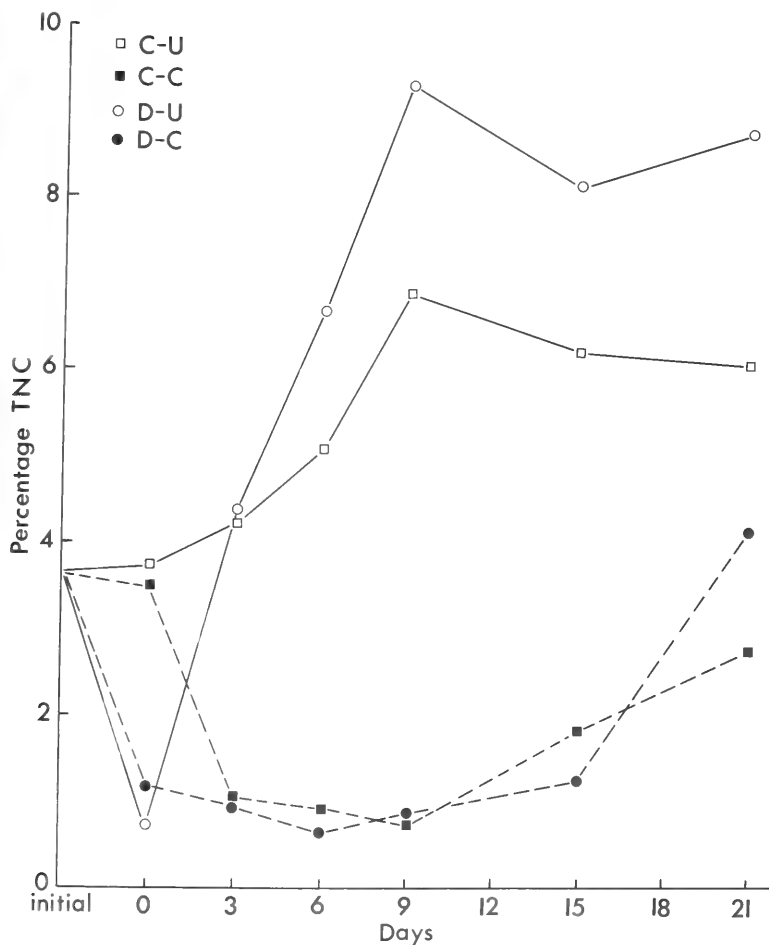


Fig.2. Changes in mean percentage TNC in the crowns following treatments

plant's requirements. This decrease was followed by a period of gradual recovery up to the end of 3 weeks. This increase indicates that sufficient leaf area had been produced so that production of assimilates by current photosynthesis was in excess of the plant's demand.

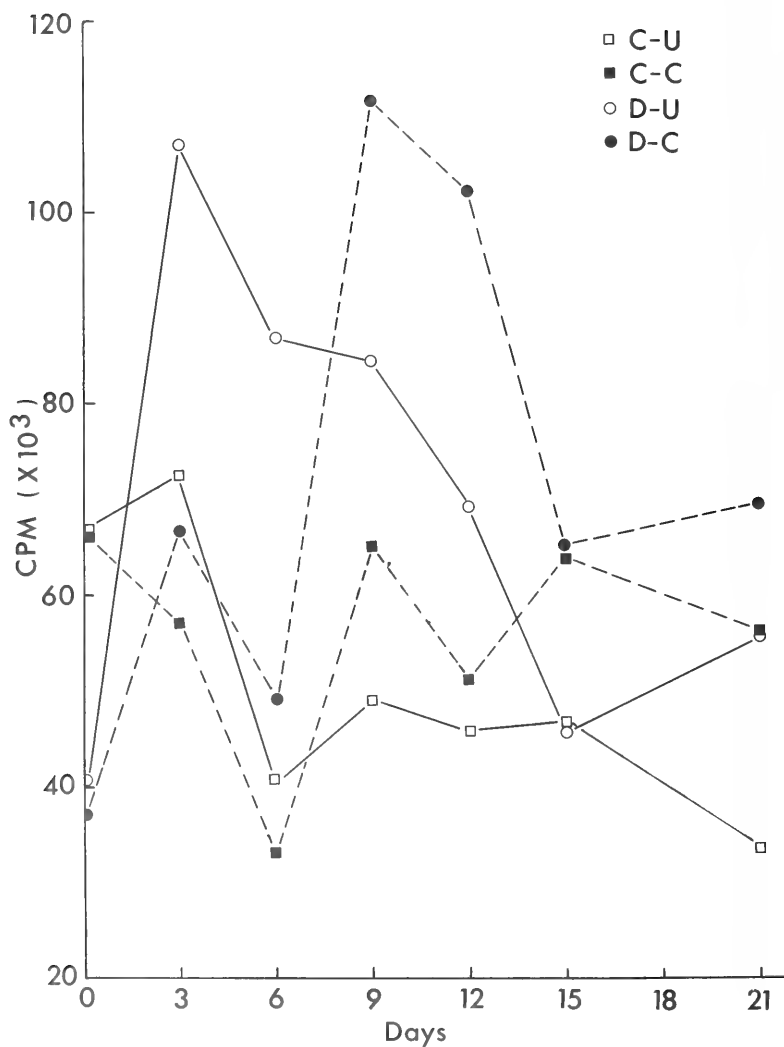


Fig.3. Changes in total plant ^{32}P following treatments.

Trends in dry mass of roots and crowns for the various treatments were similar to those of percentage TNC and are therefore not presented.

Plants depleted of carbohydrates by the dark treatment absorbed significantly less ^{32}P than the control plants on day 0 (Fig. 3).

Lower phosphate absorption by plants depleted of carbohydrates could probably be attributed to the lack of sufficient carbohydrate reserves for active uptake (Fig. 1). That reserve carbohydrates played an important role in phosphate uptake was further suggested by significant correlations between root TNC and total plant ^{32}P .

Intact plants from the dark treatment (D-U) translocated significantly lower proportions of ^{32}P to the crowns and leaves than the corresponding control treatment (C-U) on day 0 (Figs 4, 5 & 6). For example, in the C-U treatment 5.42% of the label was located in the crown and 3.18% in the leaves. In the D-U treatment 1.7% of the labelled phosphate was located in the crown and 0.57% in the leaves. In the crowns of defoliated plants (Fig. 5) the D-C treatment had significantly lower ^{32}P (1.38%) than the C-C treatment (8.05%).

The rate of ^{32}P uptake decreased when plants were maintained in darkness (results not presented). Plants maintained in darkness for 3 days were probably lower in phosphate than those that were illuminated. Differential phosphorus uptake by phosphorus-stressed maize plants was also demonstrated by Clark & Brown (1974). Reduced phosphate translocation to crowns of dark-treated plants on day 0 was probably due to the rapid incorporation of phosphate into organic compounds in the roots. That such rapid incorporation occurs in roots that are low in phosphate was demonstrated by Russel & Martin (1953), Ahmad (1963) and Loughman (1966). Rapid incorporation of ^{32}P in roots that are low in phosphate is in agreement with the view that scarce metabolites are usually supplied to tissues nearest the source in preference to those further away.

The ^{32}P content of the leaves of defoliated plants on day 0 was significantly higher than those of the intact plants. During the 8 h labelling period sufficient regrowth had occurred in defoliated plants to create active sinks for phosphate.

Uptake of ^{32}P in the dark treatments (D-U and D-C) increased rapidly on day 3 (Fig. 3). In the D-U treatment maximum uptake occurred on day 3. In the D-C treatment uptake of ^{32}P reached a maximum on day 9. Increased ^{32}P absorption in the dark treatments was probably due to the restoration of phosphate pools to levels prior to the dark treatment. The energy requirements for active uptake were provided by the increasing levels of carbohydrate during the recovery period (Fig. 1). After the maximum had been obtained there was a decline in ^{32}P uptake (Fig. 3). The drop in ^{32}P uptake for all treatments on day 6 (Fig. 3) was due to an electrical failure during which time the temperature and light intensity were considerably reduced.

After day 0 trends in ^{32}P distribution among roots, crowns and leaves of intact plants were similar. In defoliated plants a major portion of the phosphate was

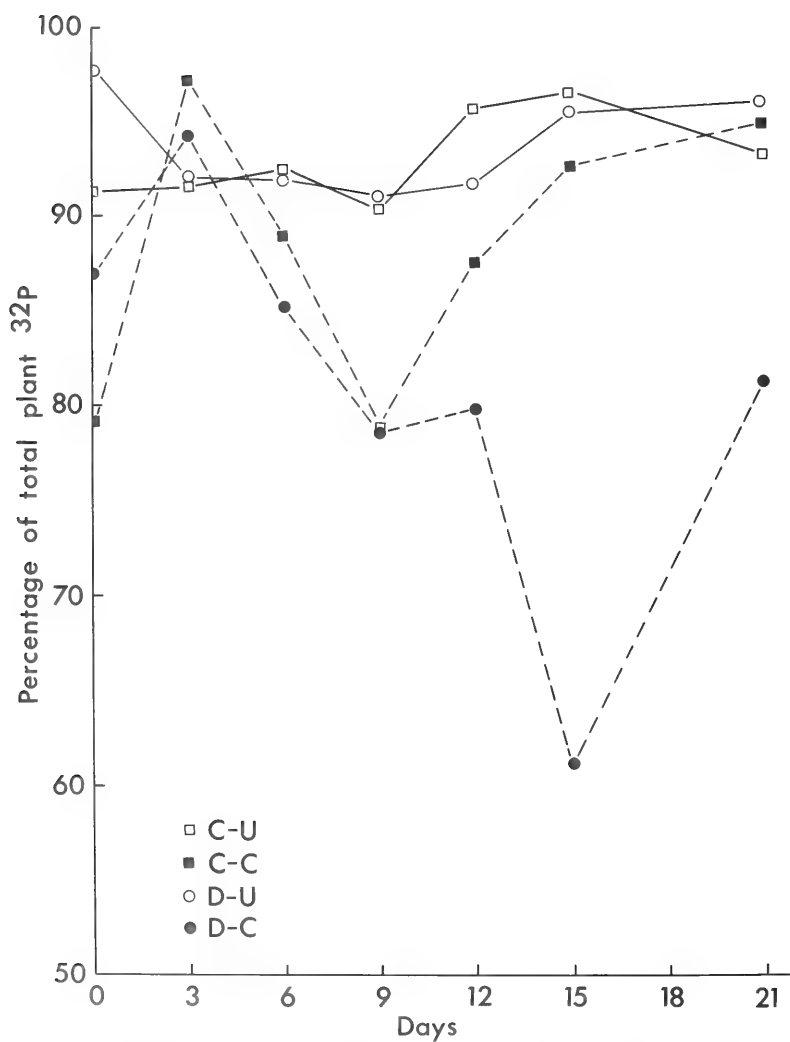


Fig.4. Changes in percentage of total plant ^{32}P in the roots following treatments.

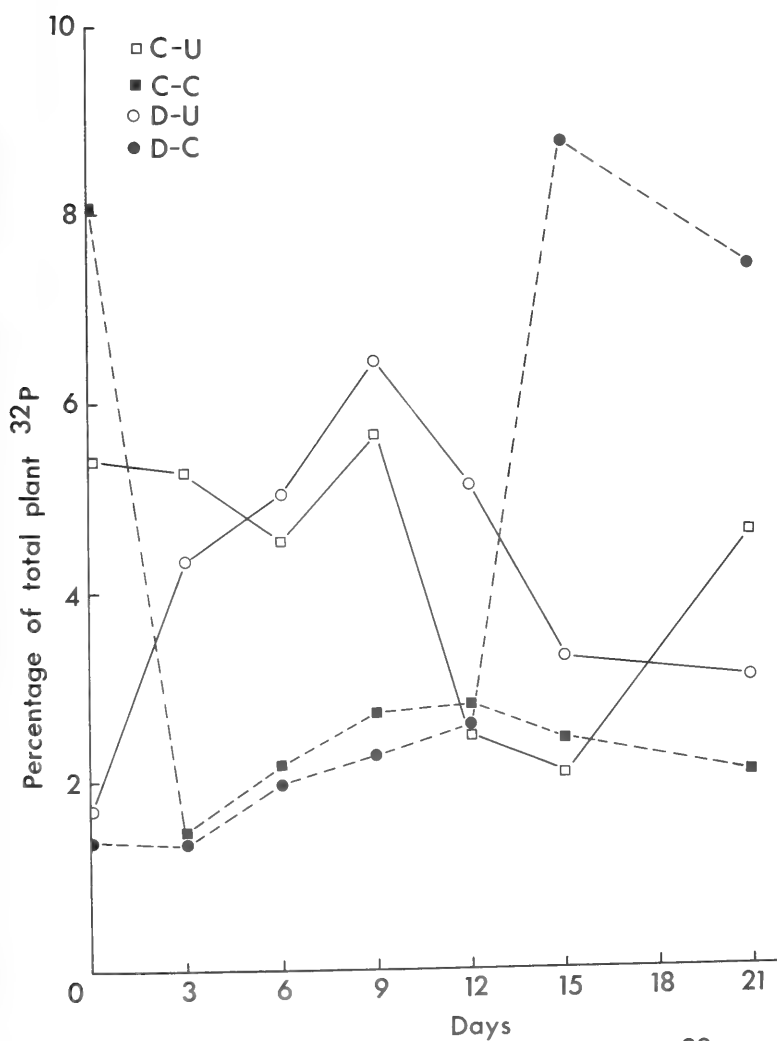


Fig.5. Changes in percentage of total plant ^{32}P in the crowns following treatments

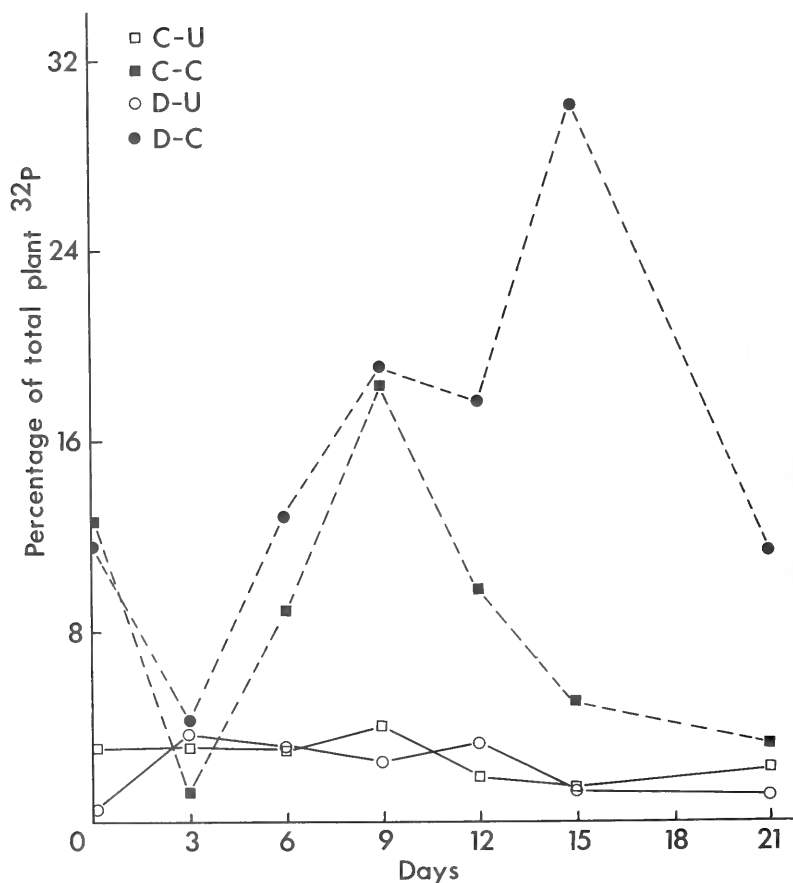


Fig.6. Changes in percentage of total plant ^{32}P in the leaves following treatments

retained within the roots on day 3 probably as a result of the effect of defoliation in depleting carbohydrate reserves (Figs 1 & 2). Thereafter there was a rapid increase in translocation of ^{32}P to the leaves as a result of rapid regrowth.

This study has revealed definite trends in phosphorus nutrition in plants under carbohydrate stress. Decrease in phosphate uptake during the dark treatment was followed by a rapid increase upon reillumination. This seems to suggest that the

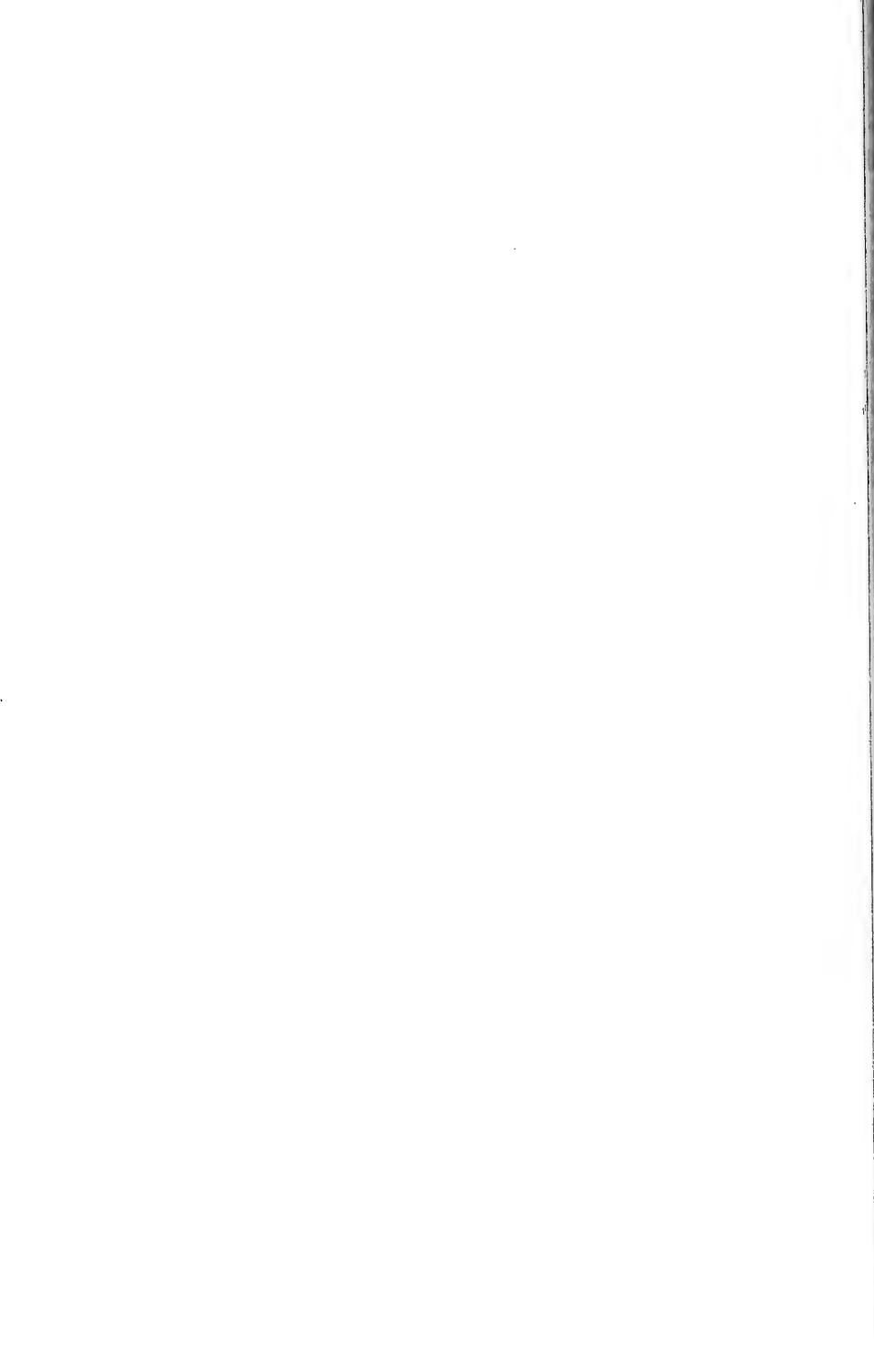
rapid ^{32}P uptake in light was probably a response to restore the pools of phosphate to levels prior to the carbohydrate depletion treatments. Increased phosphate absorption was related to an adequate supply of reserve carbohydrates.

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THE DUAL MECHANISM OF IRON ABSORPTION IN BEAN ROOT AND LEAF TISSUES

J. H. JOOSTE AND J. A. DE BRUYN

(Department of Botany, University of Stellenbosch)

ABSTRACT

The possible existence of a dual pattern of Fe uptake in root and leaf tissues of bean plants was investigated employing a modification of the tea-bag technique. Experimental solutions, consisting of FeCl_3 in 0.5 mM CaCl_2 solution, varied from 0.01–0.5 mM in the "low" range and from 1–30 mM in the "high" range. Absorbed Fe was determined by means of atomic absorption spectroscopy and radiometric analysis.

The Fe uptake curves for both root and leaf tissues displayed a hyperbolic rise followed by a plateau in the low concentration range, and an exponential increase in the high concentration range. The possibility exists that Fe in the high concentration range is precipitated in the tissues.

UITTREKSEL

DIE TWEEFASE MEGANISME VAN YSTEROPNAME IN WORTEL- EN BLAAR- WEEFSEL VAN DIE BOONTJIEPLANT

Die moontlikheid dat Fe-opname in wortel- en blaarweefsel van die boontjieplant volgens 'n tweefase patroon geskied, is ondersoek deur van 'n wysiging van die teesakkie-tegniek gebruik te maak. Eksperimentele oplossings bestaande uit FeCl_3 in 'n 0.5 mM CaCl_2 -oplossing het van 0.01–0.5 mM in die "lae" gebied en van 1–30 mM in die "hoë" gebied gevarieer. Opgeneemde Fe is deur middel van atoomabsorpsie-spektroskopie en radiometriele analise bepaal.

Die krommes vir Fe-opname deur sowel wortel- as blaarweefsel het 'n hiperboliese styging gevolg deur 'n plato-gebied in die lae konsentrasiereeks, en 'n eksponensiële toename in die hoë konsentrasiereeks vertoon. Die moontlikheid bestaan dat Fe in die weefsel mag neerslaan in die hoë konsentrasiegebied.

INTRODUCTION

Epstein and others found that the rate of ion uptake over a wide concentration range follows two distinct patterns differing in magnitude (Epstein, 1966; Torii and Laties, 1966). On account hereof it has been suggested that there are at least two mechanisms of ion uptake—one operating at an external ion concentration up to 1 mM (mechanism 1) and the other from 1 mM upwards (mechanism 2).

Such a two-phase pattern of uptake has been obtained with a number of cations and anions. Epstein (1976) lists several experiments in which the biphasic absorption pattern was obtained. Out of a total of 61 experiments only six were conducted with divalent cations, of which one was with Fe. In that particular investigation it was found that Fe uptake by excised rice roots displayed a duality in uptake (Kannan, 1971).

On account of the above findings it was decided to investigate the possible existence of a dual pattern of Fe uptake in root and leaf tissues of bean plants.

MATERIAL AND METHODS

Seeds of kidney bean (*Phaseolus vulgaris* L. cv. Top Crop) were germinated in quartz sand moistened with deionised water. After 10 days the seedlings were transferred to containers filled with full-strength culture solution—solution 1 of Hoagland and Arnon (1938), but with Fe-EDTA as Fe source—and allowed to grow for a further 10 days in a growth chamber—daily photoperiod 14 h (28 ± 2 °C) and light intensity of c. 9000 lux.

At this time, discs 5 mm in diameter were cut from the two youngest fully-expanded leaves, and the young root tips (10–15 mm) were excised. Both leaf discs and root tips were immediately transferred to deionised water. Each sample consisted of 50 leaf discs and an equal fresh mass (c. 0.3 g) of root tips.

The tissue samples were then transferred to nylon gauze bags divided into separate compartments—an adaptation of the tea-bag technique of Epstein, Rains and Elzam (1963)—in order to ensure that both root and leaf tissues were subjected to strictly comparable conditions. The bags were thereupon placed in an aerated intermediate solution of 0.5 mM CaCl_2 , kept at 30 °C for one h, and subsequently transferred to the experimental solution, from which the uptake of Fe was studied. The latter was also continuously aerated and kept at 30 °C in a water bath in diffuse light.

Experimental solution

In preliminary trials, experimental solutions at pH 5.3 were used. However, since extremely variable and inexplicable results were obtained (e.g., absorption decreased, rather than increased with time), and Fe tended to precipitate above pH 3.2, subsequent experimental solutions were adjusted to pH 3.2 with dilute HCl. At least 150 ml of experimental solution per bag (containing 0.3 g each of leaf discs and root tips) were used.

The concentration of Fe (as FeCl_3 , in 0.5 mM CaCl_2 solution) varied from 0.01 to 0.5 mM ("low" range), and from 1–30 mM ("high" range). In one series of investigations ^{59}Fe was added as a tracer to the experimental solutions (2 μCi ^{59}Fe per litre, as FeCl_3 , obtained from the Radiochemical Centre, Amersham). In the second series of experiments, the actual amount of Fe in the tissues was determined by means of atomic absorption spectroscopy.

In all experiments the absorption period was 20 minutes; in the second series this was followed by desorption in a 10 mM Na_2EDTA solution for 20 minutes at 2 °C.

Analysis of plant material

Following the absorption periods in the different experimental solutions, each sample was rinsed for a total of one minute in a separate series of four beakers

each containing 200 ml deionised water. Where a desorption treatment was employed, the samples were then transferred to the desorption solution, following which they were rinsed again as above. Where ^{59}Fe had been used, radioactivity of the tissues was determined by means of a well scintillation counter. Corrections were made for radioactive decay and the total amount of Fe was calculated. Where the Fe content of the samples was determined by means of atomic absorption spectroscopy, the method of Allen (1970) was employed.

Statistics

Two replicates of each treatment were employed; each experiment was repeated on two consecutive days. The mean and standard error for each treatment were calculated. Differences between means of more than twice the standard error were regarded as significant.

RESULTS AND DISCUSSION

In Figures 1 and 2 the pattern of Fe uptake are shown with and without a desorption treatment respectively. The similarity in the shape of the curves is very striking. According to Torii and Laties (1966), the uptake of chloride in the range of 0–0.5 mM is hyperbolic; at high concentrations (1–50 mM) a second, multiple hyperbolic isotherm is obtained in the case of vacuolated tissues, whereas the isotherm for non-vacuolated tissue rises exponentially. According to these authors

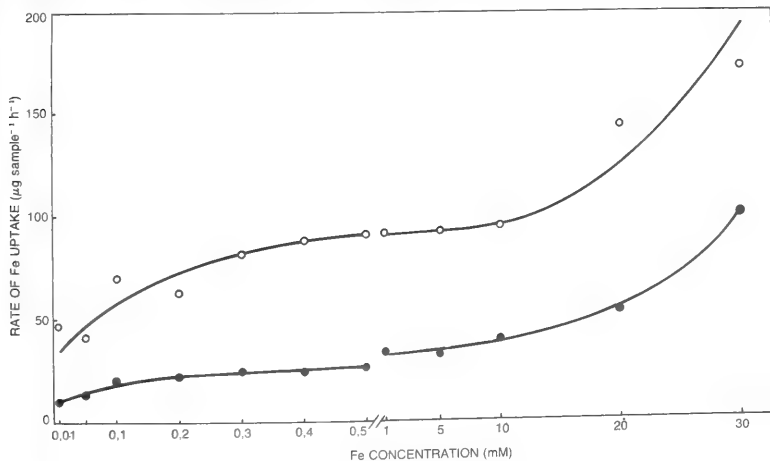


FIG. 1.

Rate of Fe absorption by bean leaf discs (●—●) and excised root tips (○—○) at low (0.01–0.5 mM) and high (1–30 mM) concentration ranges of Fe. Fe supplied as FeCl_3 in 0.5 mM CaCl_2 solution. Absorption period 20 minutes at 30 °C, followed by desorption in 10 mM $\text{Na}_2\text{-EDTA}$ at 2 °C for 20 minutes.

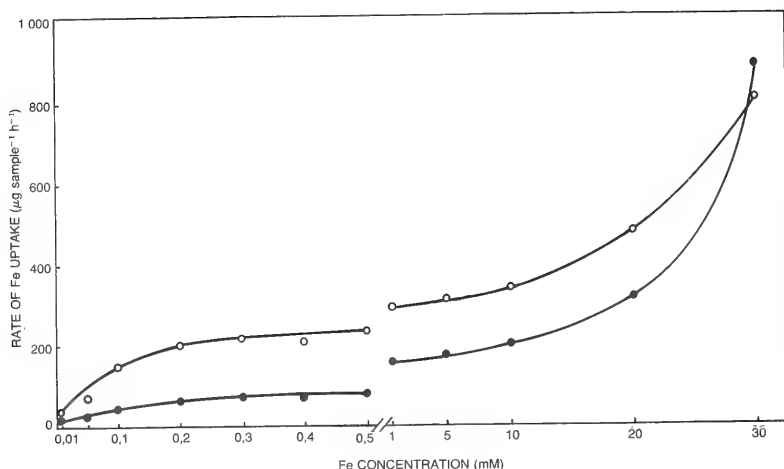


FIG. 2.

Rate of Fe absorption by bean leaf discs (●—●) and excised root tips (○—○) at low (0.01–0.5 mM) and high (1–30 mM) concentration ranges of Fe. Fe supplied as FeCl_3 labelled with ^{59}Fe in 0.5 mM CaCl_2 solution. Absorption period 20 minutes at 30 °C.

a linear to exponential increase is an indication of uptake by diffusion. It must be assumed that the tissues in this investigation (leaf discs and root tips) were vacuolated, as were the rice roots in the investigations of Kannan (1971).

As mentioned earlier, Kannan (1971) claims that Fe uptake by excised rice roots displays the dual pattern of uptake. According to his findings the absorption isotherm in the low concentration range is hyperbolic, whereas it is almost linear in the high range. He further applies the Lineweaver-Burk kinetic analysis to his data in both the low and high concentration ranges, whereas according to Epstein (1972) this should not be possible in the case of the high concentration range (mechanism 2).

A Lineweaver-Burk kinetic analysis of the present results yielded a straight-line relationship in the low concentration range for both root tips and leaf discs (Fig. 3). However, this relationship was not obtained in the high concentration range. This is in contrast to the findings of Kannan (1971) with excised rice roots.

If a dual pattern of uptake is considered as a first followed by a second hyperbolic isotherm as originally suggested by Epstein (1966), the conclusion can be drawn that Fe uptake by root and leaf tissues of the bean plant displays no true dual pattern. If, however, a curve displaying a hyperbolic rise and a plateau area, followed by either a hyperbolic, linear, or even an exponential increase, is still considered as indicative of a two-phase uptake pattern, the uptake of Fe in the present investigation can also be regarded as biphasic.

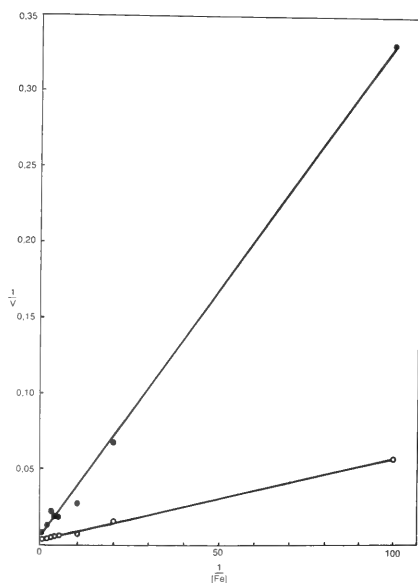


FIG. 3.

Kinetic analysis of results in Figure 2—low concentration range (0.01–1 mM Fe). ●—● leaf discs; ○—○ root tips.

The possibility exists that Fe in the high concentration range is precipitated in the tissue, which might explain the exponential rise of the curves. Tissue damage due to the high Fe concentrations with accompanying passive inward movement, appears unlikely, since in that case one would expect the desorption treatment with the chelate to remove that part of the absorbed Fe, which apparently did not occur (compare Figures 1 and 2).

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DESORPTION OF ABSORBED IRON IN BEAN ROOT AND LEAF TISSUES

J. H. JOOSTE and J. A. DE BRUYN

(*Department of Botany, University of Stellenbosch*)

ABSTRACT

The effect of different desorption media on the amount of absorbed Fe (from a solution of FeCl_3 in 0,5 mM CaCl_2) retained by leaf discs and excised root tips of bean plants was investigated. Attempts were also made to determine the effect of desorption on the intracellular distribution of Fe.

Desorption in water or an FeCl_3 solution had no pronounced effect on the amount of absorbed Fe retained by either the leaf or root tissues. However, $\text{Na}_2\text{-EDTA}^1$ was able to desorb a considerable portion of the absorbed Fe, especially in root tissue. This applies to Fe absorbed from solutions of FeCl_3 and Fe-EDDHA.²

Desorption by the chelate removed Fe from practically all the different particulate fractions of both root and leaf tissues, but desorption following the longer absorption periods resulted in an increase in the Fe content of the "soluble" fraction.

The possibility that $\text{Na}_2\text{-EDTA}$ causes an increased permeability of cell membranes seems likely. The view that removal of Ca by the chelate causes this increase in permeability could not be confirmed.

UITTREKSEL

DESORPSIE VAN OPGENEEMDE YSTER IN WORTEL- EN BLAARWEEFSEL VAN DIE BOONTJIEPLANT

Die effek van verskillende desorpsiemedia op die hoeveelheid opgeneemde Fe (uit 'n oplossing van FeCl_3 in 0,5 mM CaCl_2) wat deur blaarskyfies en afgesnyde wortelpunte van die boontjieplant behou word, is ondersoek. Ook is gepoog om die effek van desorpsie op die intrasellulêre verspreiding van Fe te bepaal.

Desorpsie in water of in 'n FeCl_3 -oplossing het geen noemenswaardige effek gehad op die hoeveelheid opgeneemde Fe wat deur of blaar- of wortelweefsel behou is nie. $\text{Na}_2\text{-EDTA}$ het egter die onttrekking van 'n aansienlike gedeelte van die opgeneemde Fe, veral in wortelweefsel, tot gevolg gehad. Dit geld vir Fe wat uit oplossings van FeCl_3 en Fe-EDDHA opgeneem is.

Desorpsie deur die chelaat het Fe uit al die verskillende selfraksies van sowel wortel- as blaarweefsel verwyder, maar desorpsie na langer tydperke van opname het die Fe-inhoud van die „oplosbare” fraksie verhoog.

Die moontlikheid dat $\text{Na}_2\text{-EDTA}$ 'n verhoogde deurdringbaarheid van selmembrane veroorsaak, lyk waarskynlik. Die opvatting dat verwydering van Ca deur die chelaat hierdie toename in deurdringbaarheid veroorsaak, kon nie bevestig word nie.

INTRODUCTION

Jeffreys (1962) concluded that Fe absorbed by discs of potato tissue may be divided into two fractions, viz., EDDHA-removable and EDDHA-resistant. The

¹ $\text{Na}_2\text{-Ethylenediamine tetraacetic acid}$.

² $\text{Fe-Ethylenediamine di(o-hydroxyphenyl acetic acid)}$.

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former represents intact Fe-EDDHA molecules bound to anion binding sites in the tissues, whereas the latter consists of Fe which has been released by the chelate and bound by the tissues. It is not clear where these two fractions are situated in the cell.

Although cell fractionation methods have been used to study the intracellular distribution of Fe (e.g. by Murphy and Maier, 1967), and desorption treatments have been used to differentiate between active and passive uptake of Fe by enzymically isolated tobacco leaf cells (Kannan, 1969) and by excised rice root tips (Kannan, 1971), no attempts have been made to study the effects of desorption on the intracellular distribution of Fe.

In this investigation different desorption media were employed and attempts were made to determine the effect of desorption on the intracellular distribution of Fe.

MATERIAL AND METHODS

Leaf discs and excised root tips were obtained from bean plants (*Phaseolus vulgaris* L., cv. Top Crop) as previously described (Jooste and De Bruyn, 1979).

Experimental solutions

Unless stated otherwise, experimental solutions consisted of 5 mg l⁻¹ Fe (as FeCl₃) in 0.5 mM CaCl₂ solution, adjusted to pH 3.2 with dilute HCl (Jooste and De Bruyn, 1978), and aerated while maintained at 30 °C. In one investigation, Fe-EDDHA was also used as a source of Fe. With one exception, 2 µCi ⁵⁹Fe (as FeCl₃; Radiochemical Centre, Amersham) were added per litre of experimental solution.

Desorption media

Where desorption treatments were applied, samples were transferred from the experimental solutions to one or more of the following media: water; FeCl₃ containing 5 mg l⁻¹ Fe, but without ⁵⁹Fe; and 10 mM Na₂-EDTA. All the desorption media (at least 250 ml per sample) also contained 0.5 mM CaCl₂ and were maintained at 2 °C. Unless stated otherwise, the desorption period was 30 minutes.

Intracellular distribution of Fe

In these experiments, each sample consisted of 80 leaf discs of 5 mm diameter, or its equivalent fresh mass of excised root tips (c. 0.45 g). After removal from the experimental solution or desorption medium, each sample was rinsed in deionised water for one minute, then immediately placed in liquid nitrogen, and transferred to a freezer (-20 °C) after 1-2 h. The samples were subsequently fractionated according to the method described by Bonner (1965). They were ground in a glass

homogeniser, in a medium consisting of 0,30 M sucrose and 0,05 M tris-HCl buffer, pH 7,0, at c. 2 °C, and then subjected to differential centrifugation in an International B-20 centrifuge at 4 °C. Cell walls were precipitated at $25 \times g$ for 5 minutes, nuclei at $100 \times g$ and chloroplasts at $2\,000 \times g$, both for 10 minutes, and mitochondria at $10\,000 \times g$ for 20 minutes; the supernatant was regarded as the "soluble" fraction.

For the purpose of radioassay, the amount of ^{59}Fe in the experimental solution was increased from 2 μCi to 20 $\mu\text{Ci l}^{-1}$.

Following its immersion in an experimental solution or (where used) a desorption medium, each sample which was not to be fractionated, was rinsed in a series of 4 beakers, each containing 200 ml deionised water, for a total of one minute. The sample was then dried at 80 °C, wet-ashed, and its ^{59}Fe content determined by means of a well scintillation counter. After making corrections for radioactive decay, the amount of Fe absorbed was calculated.

In determining the Fe content of the different subcellular fractions, the material was not ashed, but transferred to the scintillation vials and made up to 5 ml with deionised water. A correction was made for the fact that the material was not equally distributed throughout the medium (Haasbroek, private communication).

Where the Ca content of the tissues was determined, atomic absorption spectroscopy was employed, according to the method of Allen (1970).

Statistics

Two or four replicates of each treatment were used; each experiment was repeated on two consecutive days. Where possible, the mean and standard error for each treatment were calculated. Differences between means of more than twice the standard error were regarded as significant.

RESULTS AND DISCUSSION

In general, desorption in water or an FeCl_3 solution had no pronounced effect on the amount of absorbed Fe retained by either the leaf or root tissues (Table 1), after the first hour. During the early stages of absorption, however, a portion of the absorbed Fe appeared to move outwards by diffusion or ion exchange. $\text{Na}_2\text{-EDTA}$ was able to desorb a considerable portion of the Fe absorbed by the leaves during the first 30 minutes, but not after longer absorption periods; it could, however, desorb the major portion of the Fe absorbed by the roots, even after the longest absorption time of two hours.

In order to determine whether chelated Fe might be more resistant than Fe^{3+} to desorption by $\text{Na}_2\text{-EDTA}$, Fe was supplied in the experimental solution at 5 mg l^{-1} as both FeCl_3 and Fe-EDDHA , and the effects of desorption in 10 mM $\text{Na}_2\text{-EDTA}$ determined. In general, more Fe was absorbed from the FeCl_3 solution than from the chelate, but the percentage change in Fe content due to desorption was very much the same (Table 2). Again a smaller percentage of Fe was

TABLE 1.

Effect of different desorption media on the amount of absorbed Fe retained by leaf discs and root tips. Experimental solution contained 5 mg l^{-1} Fe (as FeCl_3). Desorption media: water, FeCl_3 solution containing 5 mg l^{-1} (without ^{59}Fe), and $10 \text{ mM Na}_2\text{-EDTA}$ solution. Desorption period 30 minutes at 2°C . Sample size 0.3 g (fresh mass). Average of 4 replicates.

Absorption period (Min.)	Fe content (μg per sample)							
	Leaf discs				Root tips			
	Desorption treatment				Desorption treatment			
	No desorption	Water	Fe solution	$\text{Na}_2\text{-EDTA}$ solution	No desorption	Water	Fe solution	$\text{Na}_2\text{-EDTA}$ solution
10.....	4.7 ± 0.1	3.1 ± 0.3	3.7 ± 0.2	1.6 ± 0.1	26.7 ± 1.3	22.3 ± 2.4	20.4 ± 0.7	3.7 ± 0.4
30.....	9.0 ± 0.6	6.3 ± 1.3	7.4 ± 0.1	3.3 ± 0.2	60.8 ± 5.9	43.3 ± 4.1	45.2 ± 8.0	8.4 ± 0.1
60.....	10.2 ± 0.8	9.8 ± 0.6	9.4 ± 0.0	7.2 ± 1.6	66.1 ± 0.8	54.2 ± 0.9	50.5 ± 2.9	13.9 ± 2.3
120.....	14.3 ± 0.2	16.0 ± 0.5	17.1 ± 1.5	14.9 ± 0.1	68.1 ± 4.6	69.7 ± 2.0	68.9 ± 5.2	30.0 ± 0.2

desorbed from the leaves than from the roots, especially after the longer absorption periods.

TABLE 2.

Effect of FeCl_3 vs. Fe-EDDHA as sources of Fe on the amount of Fe absorbed by leaf discs and root tips, before and after desorption in 10 mM $\text{Na}_2\text{-EDTA}$ for 30 minutes. Fe supplied at 5 mg l^{-1} ; sample size 0,3 g (fresh mass). Average of 4 replicates.

Absorption period (Min.)	Fe content (μg per sample)					
	FeCl_3			Fe-EDDHA		
	No desorption	After desorption	% Change	No desorption	After desorption	% Change
Leaf discs						
10	$6,0 \pm 0,1$	$2,7 \pm 0,5$	-54	$3,5 \pm 0,8$	$1,9 \pm 0,0$	-46
30	$12,9 \pm 1,1$	$7,5 \pm 0,9$	-42	$7,9 \pm 0,4$	$4,8 \pm 0,8$	-39
60	$26,5 \pm 1,0$	$16,2 \pm 1,6$	-39	$12,9 \pm 0,4$	$8,7 \pm 0,6$	-33
120	$45,4 \pm 6,6$	$38,7 \pm 8,3$	-15	$22,5 \pm 1,0$	$20,4 \pm 2,6$	-9
Root tips						
10	$27,8 \pm 2,7$	$10,7 \pm 0,3$	-62	$21,1 \pm 5,4$	$7,2 \pm 0,3$	-66
30	$63,9 \pm 4,0$	$28,7 \pm 1,7$	-55	$42,0 \pm 10,2$	$16,2 \pm 1,6$	-61
60	$101,1 \pm 3,1$	$41,4 \pm 2,1$	-59	$64,6 \pm 5,9$	$24,5 \pm 1,6$	-62
120	$138,4 \pm 19,2$	$75,1 \pm 14,8$	-46	$77,9 \pm 15,6$	$41,6 \pm 5,0$	-46

The possibility that a desorption period of 30 minutes might be insufficient to effect complete desorption of the "removable" Fe was investigated by studying the effects of different desorption periods. Results (not included) indicated that desorption is essentially completed after 5 minutes. Desorption of Fe by $\text{Na}_2\text{-EDTA}$ therefore appears to be quite rapid.

These findings raised the question: from which part of the cell or tissue is absorbed Fe removed by $\text{Na}_2\text{-EDTA}$? The following experiment was therefore carried out: Root tips and leaf discs were allowed to absorb Fe for different periods, after which some of the samples were subjected to a desorption treatment in 10 mM $\text{Na}_2\text{-EDTA}$. The plant material was ground up and separated into cell wall, nucleus, chloroplast, mitochondrion and supernatant fractions by means of differential centrifugation. The results of this investigation are presented in Tables 3 and 4.

Table 3 shows that the total amount of Fe per sample as well as the Fe content of practically all the particulate fractions of both leaf and root tissues, decreased as a result of desorption. In contrast, desorption following absorption periods of 60 minutes and longer, resulted in an increase in the Fe content of the soluble fraction (Table 4). More Fe (percentage wise) was withdrawn from the root cell walls and nuclei than from those of the leaf cells (Table 4).

TABLE 3.

Intracellular distribution of absorbed Fe before and after desorption in 10 mM Na₂-EDTA at 2 °C for 30 minutes. Experimental solution contained 5 mg l⁻¹ Fe (as FeCl₃). Sample size 0,45 g (fresh mass). Average of 2 replicates.

Absorption period (Min.)	Material	Fe content (μg per cell fraction)					
		Without desorption					
		Cell walls	Nuclei	Chloro- plasts	Mitochon.	Soluble	Total
10	Leaf discs	1,8 \pm 0,2	1,0 \pm 0,1	2,9 \pm 0,0	2,0 \pm 0,5	2,1 \pm 0,5	9,8 \pm 0,0
30		4,7 \pm 0,8	3,4 \pm 0,4	5,5 \pm 0,0	3,5 \pm 0,8	3,5 \pm 0,5	20,6 \pm 0,9
60		6,4 \pm 1,6	7,0 \pm 0,3	10,5 \pm 3,2	4,5 \pm 0,2	4,1 \pm 0,7	32,5 \pm 0,7
120		13,5 \pm 1,4	9,8 \pm 3,6	12,3 \pm 0,2	6,4 \pm 1,5	5,4 \pm 1,2	47,9 \pm 0,8
10	Root tips	9,2 \pm 2,8	5,1 \pm 1,6	—	8,1 \pm 1,6	5,5 \pm 3,1	27,9 \pm 3,5
30		12,9 \pm 3,7	9,1 \pm 3,1	—	16,2 \pm 2,4	7,0 \pm 2,1	45,2 \pm 5,1
60		15,4 \pm 4,2	20,0 \pm 2,2	—	26,0 \pm 3,2	7,9 \pm 1,4	69,3 \pm 6,5
120		27,5 \pm 9,7	10,2 \pm 2,1	—	23,0 \pm 4,7	8,1 \pm 1,1	68,8 \pm 1,7
After Desorption							
10	Leaf discs	1,4 \pm 0,1	0,5 \pm 0,1	0,6 \pm 0,1	0,3 \pm 0,1	1,7 \pm 0,1	4,5 \pm 0,2
30		2,7 \pm 0,3	1,2 \pm 0,1	2,0 \pm 0,6	0,7 \pm 0,0	3,3 \pm 0,9	9,9 \pm 0,5
60		8,3 \pm 0,9	4,4 \pm 2,1	4,3 \pm 0,2	1,8 \pm 0,1	5,6 \pm 1,1	24,4 \pm 0,3
120		11,5 \pm 0,2	4,8 \pm 0,6	4,9 \pm 0,5	2,3 \pm 0,0	7,0 \pm 1,0	30,5 \pm 1,1
10	Root tips	2,4 \pm 0,1	0,6 \pm 0,0	—	2,0 \pm 0,5	3,9 \pm 0,3	8,9 \pm 0,7
30		4,2 \pm 0,2	1,6 \pm 0,9	—	3,1 \pm 0,2	7,8 \pm 0,6	16,7 \pm 1,0
60		6,2 \pm 1,3	5,1 \pm 1,5	—	6,5 \pm 1,2	11,1 \pm 1,5	29,0 \pm 0,1
120		8,0 \pm 0,5	4,7 \pm 1,5	—	7,9 \pm 0,0	20,3 \pm 1,6	40,9 \pm 0,7

These results indicate that desorption in Na₂-EDTA removes more Fe, from both root and leaf tissues, than that apparently contained in the apparent free space. This is difficult to explain.

It is generally accepted that Ca is necessary for the maintenance of the differential permeability of cell membranes, and that monovalent ions increase their permeability (Epstein, 1972). According to Foote and Hanson (1964), treatment of soybean root tissue with EDTA causes the removal of two-thirds of the Ca from the tissue. The possibility that a desorption treatment with Na₂-EDTA may remove Ca from the tissue with a consequent damaging effect on the cell membranes, thereby making possible the removal of Fe by the chelate, was accordingly investigated. No difference in Ca content of tissue with and without a desorption treatment, could be detected notwithstanding the presence or absence of Ca in the experimental solution. In addition, no effect of Na⁺ ions could be determined. NaCl solutions, with or without Ca, were unable to remove Fe from the tissues—only Na₂-EDTA, with or without Ca in the medium, could do so.

TABLE 4.
Percentage change in the amount of absorbed Fe after desorption in 10 mM Na₂-EDTA at 2 °C for 30 minutes, following absorption periods from 10 to 120 minutes in 5 mg l⁻¹ Fe, as FeCl₃.

Absorption period (Min.)	% Increase (+) or decrease (-)*									
	Leaf discs					Root tips				
	Cell walls	Nuclei	Chloropl.	Mitochon.	Soluble fraction	Total	Cell walls	Nuclei	Mitochon.	Soluble fraction
10	-24.3	-50.0	-79.2	-84.3	-21.7	-54.8	-74.3	-87.6	-75.7	-28.6
30	-41.5	-65.7	-62.8	-81.1	-4.0	-51.6	-67.7	-82.0	-81.1	+11.2
60	+29.6	-37.4	-58.5	-60.3	+36.7	-24.9	-59.8	-74.6	-74.9	+42.9
120	-14.9	-51.7	-61.5	-63.3	+29.9	-36.2	-70.7	-53.8	-65.8	+151.1
										-40.5

*Based on results in Table 2.

Removal of Fe which has moved through differentially permeable membranes, apparently occurs during desorption in $\text{Na}_2\text{-EDTA}$. This was indicated by the finding that withdrawal of Fe from cell organelles like nuclei, chloroplasts and mitochondria took place during desorption. The possibility that cell membranes become more permeable as a result of desorption seems likely. The view that removal of Ca by the chelate causes this increase in permeability could not be confirmed. It would also appear that Na^+ ions play no role in the seemingly increased permeability of the cell membranes.

ACKNOWLEDGEMENTS

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COMPARISON OF IRON UPTAKE BY BEAN ROOT AND LEAF TISSUES

J. H. JOOSTE

(Department of Botany, University of Stellenbosch)

ABSTRACT

An attempt was made to find an explanation for the observed difference in uptake between root and leaf tissues of the bean plant, viz., higher uptake by root tips than by leaf discs in spite of a similar pattern of uptake by the two tissues.

Although leaf slices absorbed more Fe than leaf discs, the absorption was still considerably lower than by root tips. Fe absorption by enzymically isolated root and leaf cells also reflected the observed difference in uptake between root and leaf tissues.

It appears unlikely that the lower Fe uptake by leaf discs in comparison to that by root tips is related to structural aspects of the tissues.

UITTREKSEL

WORTEL- VERSUS BLAAROPNAME VAN YSTER DEUR DIE WEEFSELS VAN DIE BOONTJIEPLANT

Daar is gepoog om 'n verklaring te vind vir die waargenome verskil in opname tussen wortel- en blaarweefsels van die boontjieplant, nl., hoër opname deur wortelpunte as deur blaarskyfies ten spyte daarvan dat die patroon van opname deur die twee weefsels deurgaans dieselfde was.

Fe-opname deur blaarrepies is met opname deur blaarskyfies en wortelpunte vergelyk. Alhoewel blaarrepies meer Fe as blaarskyfies opgeneem het, was dit steeds aansienlik minder as die hoeveelheid deur die wortelpunte opgeneem. Fe-opname deur ensimatie-geïsoleerde wortel- en blaarselle het ook die waargenome verskil in opname tussen wortel- en blaarweefsel vertoon.

Dit lyk onwaarskynlik of die laer opname van Fe deur blaarskyfies in vergelyking met dié deur wortelpunte aan strukturele aspekte van die weefsels toegeskryf kan word.

INTRODUCTION

In previous work on Fe uptake by bean root and leaf tissues (Jooste and De Bruyn, 1979a, b), the pattern of absorption was similar, however root tissue absorbed considerably more Fe than leaf tissue. This raised the question whether this difference in uptake is related to structural differences or to inherent differences in uptake ability between leaf and root tissues.

By comparing Rb uptake by leaf discs, ring-shaped leaf discs, and leaf slices, Smith and Epstein (1964a) found that absorption per unit mass decreased with increased size of the tissue pieces. From this they concluded that in the larger pieces of tissue an increased percentage of the cells were not involved in absorption from the medium; only the boundary cells were capable of doing so.

A comparison of the rate of K absorption by barley roots and corn leaf tissue produced similar results (Smith and Epstein, 1964b). From this they concluded that the carriers involved in K absorption are identical in barley roots and corn leaves.

Jacoby and Plessner (1970) determined that chloride absorption by bean leaves at fairly low external concentrations amounts to approximately one-sixth of the amount absorbed by roots of the same plant. They, however, did not attempt to explain these differences.

Fe uptake by excised rice roots (Kannan, 1971) and isolated tobacco leaf cells (Kannan, 1969; Kannan and Wittwer, 1967) were studied, but Fe uptake by leaf and root tissues of the same species have not been compared.

In view of the foregoing, an attempt was made to find an explanation for the observed difference in uptake between root and leaf tissues of bean.

MATERIAL AND METHODS

The two youngest fully expanded leaves and excised root tips from bean plants (*Phaseolus vulgaris* L., cv. Top Crop) grown as previously described (Jooste and De Bruyn, 1979a) were used as experimental material.

Two experiments were conducted. In the first experiment, Fe uptake by leaf discs (5 mm diameter) and root tips (10–15 mm long) was compared to uptake by leaf slices, 2 mm wide and cut from leaves of which the main veins had been removed. An equal fresh mass (c. 0.23 g) of leaf discs, leaf slices, and root tips were placed in nylon gauze bags with 3 compartments, which were thereupon placed in the experimental solution.

The experimental solution contained 5 mg l^{-1} Fe (as $FeCl_3$) in 0.5 mM $CaCl_2$ solution adjusted to pH 3.2, and aerated while maintained at 30 °C. Following absorption periods of 30 and 120 minutes, half of the samples were subjected to a desorption treatment in 10 mM Na_2 -EDTA at 2 °C for 30 minutes.

In the second experiment, Fe absorption by enzymically isolated root and leaf cells was investigated. A modification of the method of Jyung, Wittwer and Bukovac (1965), for the separation of cells, was followed. Slices, 2 mm wide, were cut from leaves; root tips were cut into segments of 2 mm. Because preliminary trials showed that separated root cells could not be obtained easily, and the above authors also indicated that difficulty is experienced in isolating cells from bean roots, the root segments were lightly crushed between two glass plates. The concentration of pectinase (Sigma Chemical Company) in the separation medium was doubled to 0.4 %, and an acetic acid-sodium acetate buffer at pH 4.0 instead of a tris maleate buffer at pH 6.4, was used. In addition the separation medium contained the following: glycerol—0.2 %, peptone—0.2 %, sucrose—0.1 M, EDTA—0.02 M, K-citrate—0.01 M, and Na-succinate—0.01 M.

Approximately 10 g leaf slices and 20 g root segments were shaken in the separation medium for 90 minutes. (Less material and shorter periods yielded

unsatisfactory results.) The supernatant was decanted through fine nylon gauze and centrifuged at $350 \times g$ for 20 minutes. Cold 0,35 M sucrose solution was added to the residue and centrifugation at $350 \times g$ for 20 minutes was repeated. After microscopic examination, 0,5 g root cells and 1 g leaf cells were each made up to 50 ml with 0,35 M sucrose solution. From these suspensions 5 ml per sample were added to the experimental solution in the Fe uptake studies.

The experimental solution contained the following: 5 mg l^{-1} Fe (as $FeCl_3$), 0,5 mM $CaCl_2$, and 0,35 M sucrose. The pH was maintained at 3,2 with a glycine buffer. For each sample 25 ml of the experimental solution were used. To this was added 0,6 μCi ^{59}Fe . Absorption periods were 30 and 120 minutes.

Absorption was discontinued following centrifugation of the cells at $500 \times g$ for 20 minutes. The supernatant was decanted and 0,35 M cold sucrose solution added, followed by another centrifugation at $500 \times g$ for 20 minutes.

In both experiments the amount of absorbed Fe was determined radiometrically.

RESULTS AND DISCUSSION

Although Fe absorption was higher by leaf slices than by leaf discs (Table 1), it was still considerably less than the amount absorbed by root tips. Withdrawal of absorbed Fe by Na_2 -EDTA also occurred to about the same extent in leaf discs and leaf slices (Tables 1 and 2).

Fe absorption by isolated root and leaf cells (Table 3) still reflects the previously observed difference in uptake between root and leaf tissues. By comparing the results of Table 3 with those of Table 1, it can be calculated that separated leaf and root cells absorbed about one-fifth of the amount of Fe taken up by a corresponding fresh mass of leaf discs and root tips respectively.

In view of these findings, it appears unlikely that the lower Fe uptake by leaf discs in comparison to that by root tips, is related to structural aspects of the tissues (e.g., the presence of a cuticle in leaf tissue). The root cells apparently possess an inherently greater ability to absorb Fe than leaf cells.

In another experiment the rate of respiration of bean root tips and leaf discs was measured in a Gilson respirometer; that of the leaf tissue was found to be somewhat higher than the respiratory rate of root tissue (157 ± 3 and $134 \pm 1 \mu l g^{-1} h^{-1}$ respectively). The higher absorptive capacity of root tissue is thus not accompanied by a higher respiratory rate. The exact cause of the higher rate of Fe absorption by root cells therefore remains unresolved.

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Financial assistance from the South African Department of Agricultural Technical Services and the Atomic Energy Board is gratefully acknowledged, as is the technical assistance of Mr. L. M. Raitt.

TABLE 1.
Fe content of leaf discs, leaf slices and root tips before and after desorption in 10 mM Na₂-EDTA for 30 minutes. Fe supplied at 5 mg l⁻¹; sample size 0,23 g (fresh mass). Average of 4 replicates.

Absorption period (Min.)	Fe content (μg per sample)					
	Material					
	Leaf discs		Leaf slices		Root tips	
	No desorption	After desorption	No desorption	After desorption	No desorption	After desorption
30	8,1±0,1	4,2±0,5	11,8±0,3	7,0±0,3	44,8±1,7	17,3±1,5
120	16,7±0,6	13,3±1,1	27,7±1,8	22,3±1,0	54,0±4,3	41,6±1,1

TABLE 2.

The ratio of Fe content of desorbed and non-desorbed tissues. Based on results in Table 1.

Absorption period (Min.)	Fe content after desorption		
	Fe content with no desorption		
	Leaf discs	Leaf slices	Root tips
30	0,52	0,59	0,39
120	0,80	0,81	0,77

TABLE 3.

Fe content of enzymically isolated leaf and root cells. Fe supplied at 5 mg l⁻¹. (Average of 4 replicates.)

Absorption period (Min.)	Fe content (μg per 0,3 g isolated cells; fresh mass)	
	Leaf cells	Root cells
30	2,1 \pm 0,1	11,4 \pm 0,6
120	3,2 \pm 0,1	14,0 \pm 0,8

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A TECHNIQUE FOR THE FLUORESCENCE STAINING OF FUNGAL NUCLEI

D. J. MOGFORD

(Department of Plant Sciences, Rhodes University, Grahamstown)

ABSTRACT

The fluorochrome "Hoechst 33258" provides a rapid and specific stain for fungal nuclei.

UITTREKSEL

'N TEGNIEK OM DIE KERNE VAN FUNGI FLUORISEEREND TE KLEUR

Die fluorochrome „Hoechst 33258" is 'n vinnige en spesifieke kleur vir die kerne van fungi.

INTRODUCTION

The techniques involved in the study of fungal nuclei are frequently lengthy, and the nuclei often show only a poor affinity for the stains employed.

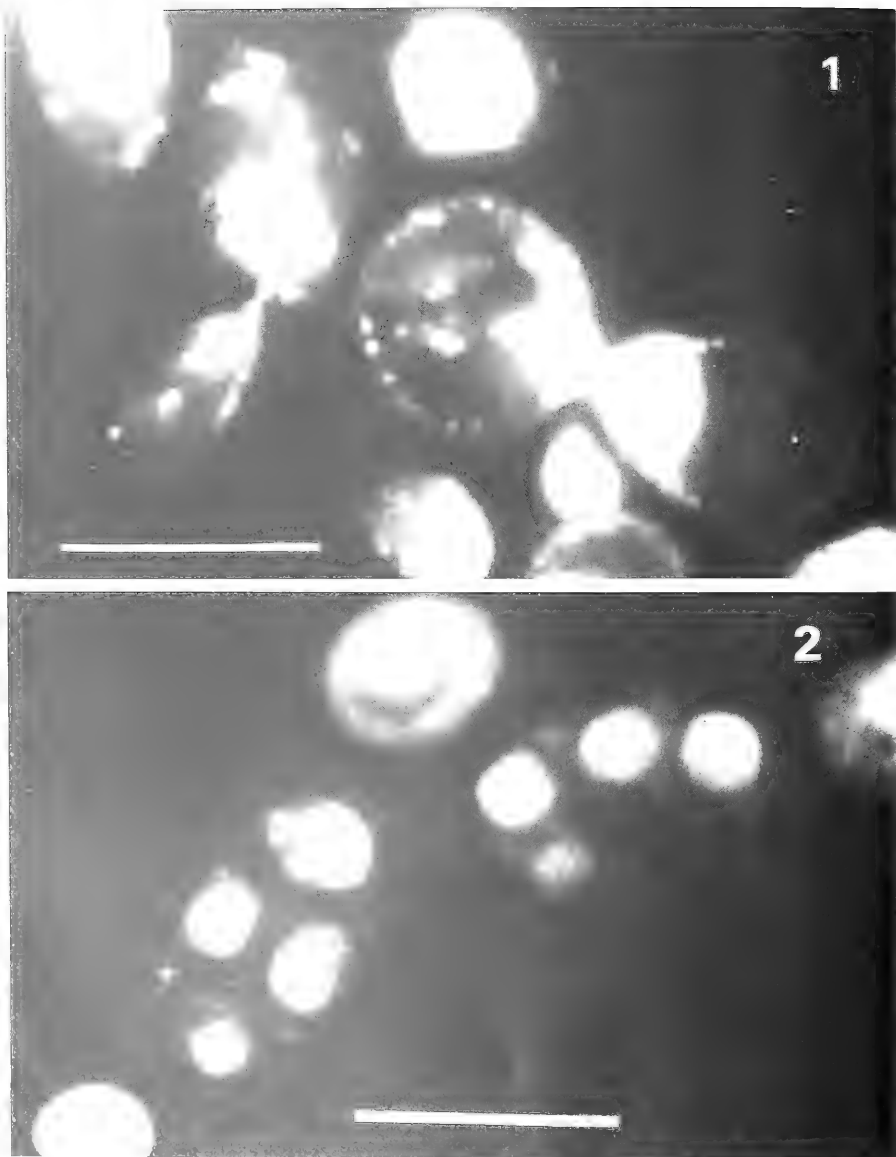
However, the development of techniques for chromosome fluorescence has offered new opportunities in the field. Lemke *et al.* (1975) developed a method based on the use of fluorescent Feulgen reagents which offered a clear visualisation of nuclei in a variety of fungi.

The present communication describes a more rapid technique based on the use of the direct, DNA-binding fluorochrome "Hoechst 33258". The compound is chemically a bibenzimidazole derivative: 2-[2-(4-hydroxyphenyl)-6-benzimidazol]-6-(1-methyl-4-piperazyl)-benzimidazol-trihydrochloride. The stain, which in fact binds preferentially to the AT-rich regions of DNA (Weisblum and Haenssler, 1974), was recently introduced as a stain for constitutive heterochromatin in mammalian chromosomes (Hillwig and Gropp, 1972), and has since found widespread application in chromosome fluorescence studies (Mogford, 1977, 1978a, b, 1979).

MATERIAL AND METHODS

Cultures of *Saccharomyces cerevisiae* Hansen were maintained on standard malt agar slopes. Clumps of cells were removed using a spatula, and fixed in 3:1 ethanol:glacial acetic acid overnight. The cells were then rinsed in distilled water, smeared on an albumenised coverslip and air-dried. The preparations were stained

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FIGS 1-2.

Saccharomyces cerevisiae, stained as described in text. Fig. 1. Vegetative cells, budding.
Fig. 2. Asci, showing nuclei within ascospores.

Bars represent 5 μ

in a 0.1% ethanolic solution of Hoechst 33258 for 10 minutes at room temperature. The stained preparations were rinsed in ethanol, air-dried, mounted in 50% glycerol and viewed using a Zeiss fluorescence microscope with exciter filter BG12 and barrier filter 50. Photographs were taken using Kodak Tri-X Pan film.

Differentiation of the nuclei was improved by storage of the completed preparations at 2 °C for periods of up to a fortnight.

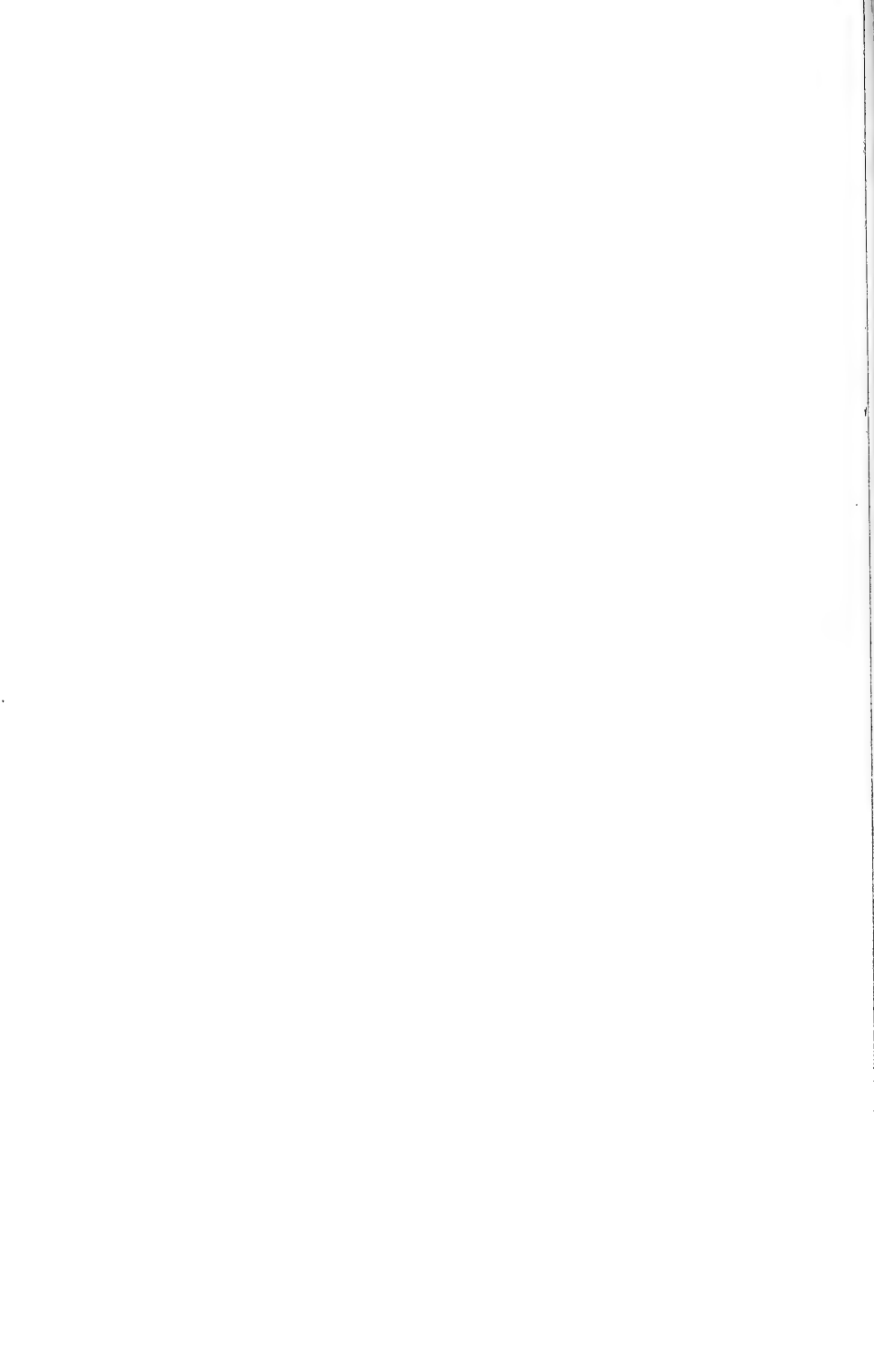
RESULTS AND DISCUSSION

The method produced a specific staining of the fungal nuclei, indicating their position within budding cells (Fig. 1) and ascospores (Fig. 2). Within vegetative cells, smaller fluorescent particles were also evident and presumably represented mitochondria or other DNA-containing organelles (Fig. 1).

It is clear that the method provides a rapid and effective alternative to conventional techniques. Its particular advantage is the removal of the hydrolysis stage necessary with most other methods. The further application of the method should yield valuable results.

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A QUALITATIVE STUDY OF THE NODULATING ABILITY OF LEGUME SPECIES: LIST 5

N. GROBBELAAR AND MARGARETHA W. VAN ROOYEN

(*Margaretha Mes Institute for Plant Physiology, University of Pretoria*)

ABSTRACT

82 legume species were examined for the presence of root nodules. Of these, three species were consistently found to be without nodules. Of the species that were examined, 69 were apparently not previously studied in this respect.

UITTREKSEL

'N KWALITATIEWE STUDIE VAN DIE VERMOË VAN PEULPLANTSOORTE OM WORTELKNOPPIES TE VORM: LYS 5

82 peulplantsoorte is vir die aanwesigheid van wortelknoppies ondersoek. Drie van die plantsoorte het deurgaans negatiewe resultate opgelewer. Van die plantsoorte wat ondersoek is, is 69 blykbaar nie vroeër vir hul vermoë om wortelknoppies te vorm ondersoek nie.

INTRODUCTION

On the basis of the number of species that it includes, the Leguminosae is the second largest family of flowering plants. Although the actual size of the family is undecided, some authorities consider the family as comprising up to 700 genera and 14 000 species. Of these, only 1 285 species were examined for root nodules by 1961 (Allen & Allen, 1961). According to that report, root nodules could not be found on 166 of the species examined. The 166 non-nodulating species were composed of 19 species of the Mimosoidae (146 species were examined); 82 species of the Caesalpinoideae (115 species were examined); and 65 species of the Papilionatae (1 024 species were examined). It would therefore appear that although all the legume sub-families do contain species which apparently never nodulate, the frequency of this feature is very high amongst the species of the Caesalpinoideae. Subsequent reports (De Souza, 1966; Grobbelaar, van Beyma & Todd, 1967; Grobbelaar & Clarke, 1972, 1974, 1975; Corby, 1974) are in general agreement with the above generalization.

This paper is an attempt to augment and corroborate the limited amount of information concerning the ability of different legume species to nodulate.

METHOD

The procedure was identical with that published earlier in greater detail (Grobbelaar, van Beyma & Todd, 1967). In most cases the plants were examined

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in the field for root nodules. In a few cases, the plants were grown from seed in pots containing sand. The pots were copiously irrigated twice a week with a nitrogen-free modification of Hoagland's nutrient solution (Hoagland & Snyder, 1933) in which the nitrates were replaced by equimolar concentrations of chlorides. In between the additions of nutrient solution, the sand was kept moist by the daily addition of tap water. If nodules did not form within a reasonable time, the sand was enriched with *Rhizobium* suspensions from available cultures and/or with soil from areas in which the species commonly occurs, when this was possible.

Annuals which failed to nodulate in at least three consecutive pot trials and perennials which did not nodulate within at least two years, were regarded as not being able to nodulate under local conditions.

Herbarium voucher specimens were prepared of all species tested. The specimens were identified at the Botanical Research Institute, Department of Agricultural Technical Services, Pretoria, and deposited in the H. G. W. J. Schweickerdt Herbarium, Department of Botany, University of Pretoria.

O. N. Allen and Ethyl K. Allen (pers. comm.), previously of the University of Wisconsin, U.S.A., have been compiling a card index of all the available data regarding the nodulation of legumes for many years.* The results of the present investigation were transmitted to them and they indicated whether other reports (published or personal) were previously received regarding the nodulating ability of the species concerned.

RESULTS AND DISCUSSION

The 82 species on which information is provided are listed in Table 1. According to Allen & Allen (pers. comm.) 69 of those species do not appear to have been studied previously for nodulation.

TABLE 1
List of legume species examined for nodulation.

Plant Species ¹	Herbarium specimen number ²	Nodulation	
		Present study ³	Allen's records ⁴
<i>MIMOSOIDEAE</i>			
<i>Ingeae</i> Benth.			
<i>Albizia anthelmintica</i> (A. Rich.) A. Brongn.	25258	+c	A
<i>A. harveyi</i> Fourn.	23619	+c	C
<i>A. lebbeck</i> (L.) Benth.	31917	+f	A
<i>A. versicolor</i> Welw. ex Oliv.	31874	+c	C
<i>Acacieae</i> Benth.			
<i>Acacia abyssinica</i> Hochst. ex Benth.	28397	+c	C
<i>A. haematoxylon</i> Willd.	31970	+c	C

*Professor O. N. Allen passed away during 1977 but the project is being continued by Dr Ethyl K. Allen, 4142 Hiawatha Drive, Madison, Wis. 53711, U.S.A.

TABLE I
List of legume species examined for nodulation.

Plant Species ¹	Herbarium specimen number ²	Nodulation	
		Present study ³	Allen's records ⁴
<i>MIMOSOIDEAE</i>			
<i>Eumimoseae</i> Benth.			
<i>Leucaena glabrata</i> Rose	34333	+c	C
<i>Adenanthereae</i> Benth.			
<i>Xerocladia viridiramis</i> (Burch.) Taub.	31136	+f	C
<i>CAESALPINIOIDEAE</i>			
<i>Cassieae</i> Benth.			
<i>Cassia abbreviata</i> Oliv. subsp. <i>beareana</i> (Holmes) Brenan	34024	—c	C
<i>Eucaesalpinieae</i> Benth.			
<i>Parkinsonia africana</i> Sond.	31124	—c	C
<i>PAPILIONATAE</i>			
<i>Sophoreae</i> Spreng.			
<i>Sophora viciifolia</i> Hance	34311	+c	A
<i>Podalyrieae</i> Benth.			
<i>Podalyria burchellii</i> DC.	34249	+f	C
<i>P. velutina</i> Burch.	34277	+f	C
<i>Genisteae</i> Bronn.			
<i>Priestleya hirsuta</i> DC.	34276	+f	C
<i>Amphithalea intermedia</i> Eckl. & Zeyh.	34256	+f	C
<i>Lotononis benthamiana</i> Duemmer	34222	+f	C
<i>L. brachyloba</i> Benth.	34287	+f	C
<i>L. corymbosa</i> Benth.	31975	+f	C
<i>L. crumanina</i> Burch. ex. Benth.	31990	+f	C
<i>L. falcata</i> Benth.	34209	+f	C
<i>L. foliosa</i> H. Bol.	31976	+f	C
<i>L. leptoloba</i> H. Bol.	34215	+f	C
<i>L. longiflora</i> H. Bol.	34220	+f	C
<i>L. magnistipulata</i> Duemmer	31889	+f	C
<i>L. maximiliana</i> Schltr.	34237	+f	C
<i>L. pentaphylla</i> Benth.	34214	+f	C
<i>L. platycarpa</i> (Viv.) Pichi-Serm. var. <i>platycarpa</i> ..	34283	+f	C
<i>L. platycarpa</i> (Viv.) Pichi-Serm. var. <i>abyssinica</i> (Hochst. ex Rich.) Pichi-Serm.	31946	+f	C
<i>L. quinata</i> Benth.	34043	+f	C
<i>L. steingroeveriana</i> Duemmer	31891	+f	C
<i>Lebeckia multiflora</i> E. Mey.	34210	+f	C
<i>L. spinescens</i> Harv.	31118	+f	C
<i>Wiborgia monoptera</i> E. Mey.	34234	+f	C

TABLE 1
List of legume species examined for nodulation.

Plant Species ¹	Herbarium specimen number ²	Nodulation	
		Present study ³	Allen's records ⁴
<i>PAPILIONATAE</i>			
<i>Aspalathus nivea</i> Thunb.	34265	+f	C
<i>Melolobium calycinum</i> Benth.	34260	+f	C
<i>M. humile</i> Eckl. & Zeyh.	34217	+f	C
<i>Crotalaria argyraea</i> Welw.	31940	+f	C
<i>C. effusa</i> E. Mey.	34229	+f	C
<i>C. excisa</i> Bak. f.	34038	+f	C
<i>C. meyerana</i> Steydel	30544	+f	C
<i>Lupinus elegans</i> H.B.K. var.	28407	+c	A
<i>Genista falcata</i> Brot.	34317	+c	C
<i>Trifolieae</i> Bronn.			
<i>Trigonella cretica</i> (L.) Boiss.	27130	—c	C
<i>Galegeae</i> Bronn.			
<i>Cyamopsis serrata</i> Schinz	31133	+f	C
<i>Indigofera amoena</i> Ait.	34247	+f	C
<i>I. aquae-nitensis</i> Bremekamp	23736	+f	C
<i>I. argyraea</i> Eckl. & Zeyh.	31134	+f	C
<i>I. argyroides</i> E. Mey.	31945	+f	C
<i>I. auricoma</i> E. Mey.	31993	+f	C
<i>I. candicans</i> Ait.	34231	+f	C
<i>I. capillaris</i> Thunb.	34254	+f	C
<i>I. charlieriana</i> Schinz	31098	+f	A
<i>I. flabellata</i> Harv.	34275	+f	C
<i>I. rautanenii</i> Bak. f.	31987	+f	C
<i>I. rhodantha</i> Fourcade	34274	+f	C
<i>I. suffruticosa</i> Mill.	34045	+c	A
<i>I. tetragonaloba</i> E. Mey.	28989	+f	A
<i>I. trita</i> L.f. subsp. <i>subulata</i> (Vahl. ex Poir.) Ali. . .	31130	+f	A
<i>Psoralea striata</i> Thunb.	34223	+f	C
<i>Tephrosia elongata</i> E. Mey. var. <i>tzaneensis</i> (H. M. Forbes) Brummitt	16932	+f	C
<i>T. glomeruliflora</i> Schinz.	31929	+f	C
<i>Requienia sphaerosperma</i> DC.	31107	+f	A
<i>Lessertia annularis</i> Burch.	31992	+f	C
<i>L. benguellensis</i> Bak. f.	31953	+f	C
<i>L. brachypus</i> Harv.	34221	+f	C
<i>L. capitata</i> E. Mey.	34238	+f	C
<i>L. diffusa</i> R. Br.	34232	+f	C
<i>L. excisa</i> DC.	34039	+f	C
<i>L. macrostachya</i> DC.	31954	+f	C
<i>L. pauciflora</i> Harv.	34031	+f	A
<i>L. spinescens</i> E. Mey.	34227	+f	C
<i>Hedysareae</i> DC.			
<i>Desmodium motorius</i> (Houtt) Merrill	36258	+c	C

TABLE 1
List of legume species examined for nodulation.

Plant Species ¹	Herbarium specimen number ²	Nodulation	
		Present study ³	Allen's records ⁴
<i>PAPILIONATAE</i>			
D. spirale DC.	33173	+c	C
D. trifolium (D. Don) G. Don	34309	+c	A
<i>Vicieae</i> Bronn.			
Abrus laevigatus E. Mey.	34307	+f	C
<i>Phaseoleae</i> Bronn.			
Rhynchosia densiflora DC. subsp. chrysendia (Taub.) Verdc.	20901	+f	C
R. dinteri Schinz	31943	+f	C
R. hirsuta Eckl. & Zeyh.	30553	+f	C
Otoptera burchellii DC.	31909	+f	A
Dolichos linearis E. Mey.	30546	+f	A
Alistilus bechuanicus N.E.Br.	31114	+f	C

1. Species are arranged alphabetically within genera. The genera are arranged according to the system of de Dalla Torre & Harms (1963).
2. Voucher specimens are kept in the HGWJ Schweickerdt Herbarium, Department of Botany, University of Pretoria.
3. A "+" indicates that nodulation was observed and a "-" that nodulation was not observed during an observation period of at least two years. Plants studied at the laboratory are indicated by a "c" whereas species examined in the field are indicated by an "f".
4. The letters A, B and C refer to information obtained by private communication from Professor O. N. Allen, Department of Bacteriology, University of Wisconsin, U.S.A.
A - nodulation previously observed
B - species investigated previously but nodulation never observed
C - species apparently not investigated previously for nodulation

Of the species listed, 3 were consistently found to be without root nodules. Two of these were members of the Caesalpinoideae; in fact, they were the only members of the Caesalpinoideae that were tested. Neither of them appears to have been investigated previously for root nodules. The other species that failed to nodulate is a member of the Papilionatae. According to Allen & Allen (pers. comm.), this species, *Trigonella cretica* (L.) Boiss, was apparently not previously investigated. In the present study, it was not possible to inoculate the sand in which the plants were grown with soil from areas in which the species, which is an exotic, normally grows.

All eight of the members of the Mimosoideae that were investigated and 71 of the 72 members of the Papilionatae that were investigated nodulated.

ACKNOWLEDGEMENTS

The financial assistance provided by the University of Pretoria and the Council for Scientific and Industrial Research is gratefully acknowledged.

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A NEW SPECIES OF *EUGENIA* L. (MYRTACEAE) FROM SOUTHERN NATAL AND TRANSKEI

A. E. VAN WYK

(H. G. W. J. Schweickerdt Herbarium, Department of Botany, University of Pretoria)

ABSTRACT

Eugenia verdoorniae Van Wyk, a new species from Southern Natal and Transkei is described.

UITTREKSEL

'n NUWE *EUGENIA*-SPESIE (MYRTACEAE) VAN SUID-NATAL EN TRANSKEI

Eugenia verdoorniae Van Wyk, 'n nuwe spesie van Suid-Natal en Transkei word beskryf.

INTRODUCTION

While working on the South African Myrtaceae a need was felt for a specific name to refer to a still unnamed *Eugenia* species which has been discovered after the revision of Dümmer (1912).

The purpose of this article is to describe this species which was first collected in 1925 in the Lusikisiki district of Transkei. Between 1925 and 1929 several herbarium specimens of it were sent to Pretoria by Mr G. Fraser, a forester stationed at the Ntsubane forest station in Transkei.

These specimens were studied by Dr I. C. Verdoorn of the Botanical Research Institute. She recognised them as belonging to a new species and, during the 1930s, prepared a preliminary description which was however never published. The name *E. fraseri* (after its discoverer) was proposed. Unfortunately this name was at that time already used for a *Eugenia* species from Borneo.

Field observations and evidence from a recent anatomical investigation (Van Wyk, 1978) confirm the distinctness of this species. I thus take pleasure in naming it after Dr Verdoorn in recognition of her contribution to the taxonomy of South African plants.

DESCRIPTION

Eugenia verdoorniae Van Wyk, sp. nov., species haec a ceteris speciebus Africae australis differt foliis perangustis et planis, margine non revolutis, costa in

statu vivo utrinque obsoleta, in statu sicco autem supra leviter canaliculata in inferiore triente tantum, infra passim valde elevata.

Est affinis illis speciebus Africae australis quae exhibent semen globosum, testam crassam lignosamque, et embryonem non conspicue glandulis punctatum.

Evergreen, androdioecious or andromonoecious, much-branched shrub or small tree, 1–3 m tall; branched from the base or with a single trunk up to 200 mm diam.; young branches reddish-brown to brown becoming grey when mature, sparingly covered with inconspicuous appressed hairs, branchlets becoming glabrous with age; internodes (4–)6–12(–20) mm long. *Leaves* decussate, petiolate; lamina dark red or pinkish when young, becoming dark green and shiny above, paler and dull below, glandular-punctate, initially covered with inconspicuous appressed hairs (especially basal third of lamina), becoming glabrous with age, narrowly elliptic to narrowly linear-lanceolate, (15–)20–40(–45) mm long, (4–)5–6(–8) mm wide, apex acute or obtuse, gradually tapering from the middle into a short petiole; venation pinnately netveined, midrib in dried leaves flat or slightly concave for basal third of length above, strongly elevated below, flat on both sides in fresh leaves; primary lateral veins alternate or opposite, 4–6 pairs, spreading, obscure above but raised below in dried leaves, obscure on both sides in fresh leaves, fused into a longitudinal slightly lobed marginal vein about 0,5 mm from the margin of the lamina, tertiary veins obscure; blade coriaceous, flat, margin entire and slightly revolute only in dried leaves; petiole 1–2 mm long, ventrally slightly canaliculate. *Inflorescences* usually short axillary few-flowered leafless racemes which often develop as leafy shoots, the number of flowers in a raceme sometimes reduced to one or two, flowers rarely solitary, sparingly pubescent; bracts often caducous. *Staminate flowers* subsessile or with pedicels 3–5 mm long, bracteoles 2, attached at the base of the hypanthium, 0,5–1 mm long, 0,3–0,4 mm wide, acute, erect, sparingly pubescent mainly on the margins. *Sepals* 4, subrotund, 2 large, 1–1,5 mm long, 1,8–2,5 mm wide, 2 small, 0,5–1,3 mm long, 1,5–2,0 mm wide, glabrous except for a few hairs on the margins, the abaxial surface sparingly gland-dotted. *Petals* 4, free, white, sometimes with a tinge of pink, more or less oval, c. 3–4 mm long, 2,5–4 mm wide, margins not ciliate, sometimes with a few (c. 5) scattered glands. *Disc* flat with a central depression, surface wrinkled, fleshy, sparingly pubescent. *Stamens* (14–)16–20(–22), arising from the disc; filaments of various lengths, (3–)4–5(–6) mm long, free to the base; anthers 2—thecous, each theca opening with a longitudinal slit, versatile, c. 1 mm long, 0,6–0,8 mm broad, all fertile. *Hypanthium* more or less obconical, c. 1 mm long, glabrous. *Ovary* abortive; style rudimentary, 0,5 mm long; stigma absent. *Bisexual flowers* subsessile or with pedicels 3–5 mm long; bracteoles as in staminate flowers. *Sepals* and *petals* as in staminate flowers. *Disc* flat with an even surface, fleshy, sparingly pubescent. *Stamens* (11–)14–16(–20), resembling those of the staminate flowers. *Hypanthium* obconical, 1,5–2

mm long. Ovary fused to the lower part of hypanthium, 2–3 locular; ovules (1–)2(–4) per locule, 1 or 2 developing; style filiform, terete, glabrous, 4–5 mm long; stigma small, slightly discoid, covered with small papillae. Fruit a fleshy red? (known only from dried specimens) berry, obovoid to subglobose, c. 18 mm diam., glabrescent with persistent calyx lobes at the apex; pericarp closely adhering to the testa—but not fused with it. Seed globose with a smooth surface, c. 10–15 mm diam.; testa woody and tough with a fibrous texture, c. 0.5 mm thick, light brown; embryo with cotyledons partly fused, light green and fleshy, not conspicuously glandular-punctate.

Flowering throughout the year, but mainly from June to July.

Type: Transkei—3129 (Port St. Johns): Mkwini river mouth, S. of Goss Point (-BD), *Van Wyk 1614* (PRE!, holo.).

DISTRIBUTION

Since its discovery, and especially during the last ten years, sporadic collections of *E. verdoorniae* have been made. The species seems to have a rather restricted distribution in Southern Natal and Pondoland where it is confined to a few scattered localities in the districts of Lusikisiki, Bizana and Port Shepstone. It usually grows on the margin of natural forests or in the open on the banks and islands of some of the larger rivers. Although common in some localities, it is a rare species in need of protection.

SPECIMENS EXAMINED

NATAL—3030 (Port Shepstone): Umtamvuna nature reserve (-CC), *Moll 5490* (PRE, NH); Umtamvuna river, *Nicholson 896* (PRE); Beacon Hill West, *Strey 7227* (NH), *Van Wyk 1681, 1682, 1696, 1700* (PRE, PRU).

TRANSKEI—3129 (Port St. Johns): Indindinde stream, below Indindinde Drift (-BD)?, *Frazer Z. 34* (PRE), s.n. sub PRF 7353 (PRE); Indindinde forest, *Fraser s.n.* sub PRF 6054 (PRE); Mkwini river mouth, S. of Goss Point (-BD), *Nicholson 941* (PRE), *Van Wyk 1614*, (PRE!, holo.) *1615, 1616, 1617* (PRE, PRU); Msikaba river mouth, *Van Wyk 1622* (PRE, PRU); Goss Point, *Strey 10157* (PRE, NH).

DISCUSSION

E. verdoorniae (Fig. 1) can easily be distinguished from the other Southern African *Eugenia* species by the following combination of characteristics: (i) narrow flat leaves with the margin not revolute; (ii) the midrib flat on both sides in fresh material; (iii) the midrib only slightly concave above, but raised below in dried leaves; (iv) seeds globose, testa thick and tough; (v) the embryo not



FIG. 1.

Eugenia verdoorniae. 1, leafy twig with flowers, $\times 1$; 2, longitudinal section of bisexual flower, $\times 6$ (both from Van Wyk 1614); 3, longitudinal section of male flower, $\times 6$ (Van Wyk 1615); 4, leaf to show venation, $\times 2$; 5, transection of fresh leaf, $\times 6$ (both from Van Wyk 1614).

conspicuously glandular-punctate; (vi) stems in which the first-formed periderm originates in the primary external phloem.

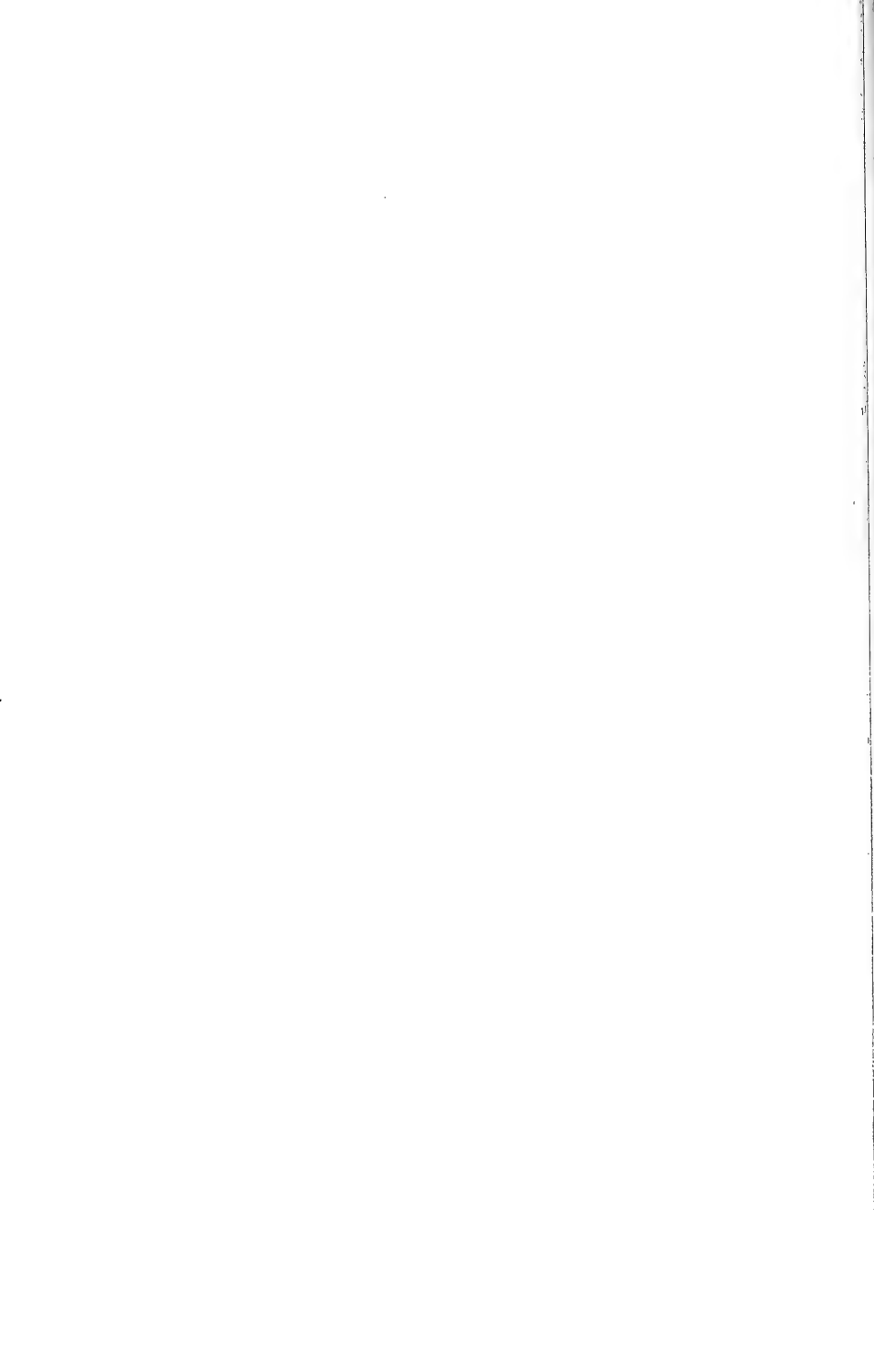
It is related to the group of species (Group Y, vide Van Wyk, 1978) that includes *E. woodii*, *E. zuluensis*, *E. albanensis*, *E. zeyheri*, *E. pusilla* and *E. erythrophylla*.

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PHENOLOGY OF THE VEGETATION IN THE HESTER MALAN NATURE RESERVE IN THE NAMAQUALAND BROKEN VELD:

1. GENERAL OBSERVATIONS

MARGARETHA W. VAN ROOYEN*, G. K. THERON AND N. GROBBELAAR

(Department of Botany, University of Pretoria)

ABSTRACT

Phenological observations were made on selected representatives of five different life form groups occurring in the Hester Malan Nature Reserve in the Namaqualand Broken Veld (Cape Province, South Africa). Phenologically the year can be subdivided into four fairly well-defined periods, viz. a mild, relatively moist autumn; a cold, moist winter; a mild, relatively moist spring and a hot, dry summer. Each period is characterized by certain phenological processes.

UITTREKSEL

'N FENOLOGIESE STUDIE VAN DIE PLANTEGROEI VAN DIE NAMAQUALANDSE GEBROKE VELD:

1. ALGEMENE WAARNEMINGS

Fenologiese gegewens van enkele verteenwoordigers van vyf verskillende lewensvormgroepe in die Hester Malan-natuurreservaat in die Namakwalandse Gebroke Veld (Kaapprovinsie, Suid-Afrika) word weergegee. Fenologies kan die jaar in vier redelik duidelik onderskeibare periodes verdeel word, naamlik: 'n matige, relatief vogtige herfs; 'n koue, vogtige winter; 'n matige, relatief vogtige lente en 'n warm, droë somer. Elke periode word deur sy besondere fenologiese aktiwiteite gekenmerk.

INTRODUCTION

The profound seasonal differences in the appearance of the Namaqualand vegetation suggest that the phenology of this vegetation type should be extremely interesting. Nevertheless, no phenological work on this area seems to have been done and this report is an attempt to rectify the matter to some extent. The investigation was carried out in the Hester Malan Nature Reserve and although most of the information presented in this paper was collected during 1974, some of the statements are based on observations that were made during periodic visits to the region over a period from 1973 to 1977.

The Hester Malan Nature Reserve is situated approximately 12 km east of Springbok between E 17° 57' and E 18° 02' and S 29° 34' and S 29° 41' and has an area of 4 479,63 ha. The reserve lies at the northern end of the Kamiesberg Range which is a region with a very broken topography. The elevation of the

*Based on an M.Sc. thesis, University of Pretoria.

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reserve varies from 884 m to 1 346 m above sea level. Geologically the area belongs to the Namaqualand Granite-Gneiss Massif (Martin, 1965) which was formed about 1 050 million years ago. Rock types on the reserve are mainly granitic gneiss and gneiss. Despite local variations, the soil is generally poorly developed and shallow with little horizontal differentiation. Along water courses, colluvial-alluvial strips occur in which the soil is impregnated with soluble salts, while the valleys and plains are covered with aeolean sand (Van der Merwe, 1940).

According to the classification of climatic regions used by the South African Weather Bureau, Namaqualand should be regarded as a desert or poor steppe (Schulze, 1965) and according to the Köppen index, the reserve borders on the BWhs and BWks climatic regions (Schulze, 1947). The region is characterized by an unpredictable annual rainfall and temperatures which show extensive daily and seasonal fluctuations. The aridity of the climate is obvious from the Walter and Lieth (1960) climatic diagram (Figure 1) in which the rainfall curve never rises above the temperature curve.

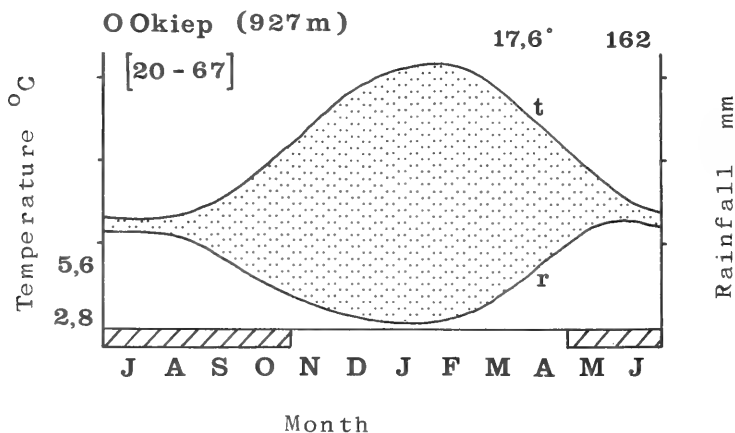


FIG. 1.
Climatic diagram for O'Okiep (Walter and Lieth, 1960).

Values for the mean monthly and annual rainfall for O'Okiep and Springbok (Weather Bureau, 1965) as well as the 1974 values for the Hester Malan Nature Reserve, O'Okiep and Springbok are provided in Table 1. The rainfall for the region is very erratic and varies considerably from year to year. Most of the annual rain falls during the four months from May to August. During 1974, however, nearly 50 % of the annual rainfall of the reserve fell during January, February and March. The exceptionally high value for March of the reserve was

due to a local cloud burst. Although April, May, July and September usually experience a relatively high rainfall, according to long-term data, they were fairly dry months during 1974. In June and August, however, the reserve received a fair amount of rain. Consequently the 1974 growing season started very early in March. This was followed by a relatively dry period during April and May whereupon June received a "normal" amount of rain. From the middle of June dry conditions once more prevailed until the August rains. Good rains towards the end of August extended the 1974 growing season into September.

TABLE 1.

Mean monthly and annual rainfall values for O'Okiep and Springbok (Weather Bureau, 1965) as well as the monthly and annual values for 1974 for the Hester Malan Nature Reserve (HMNR), O'Okiep and Springbok.* The number of rainy days per month is given in brackets.

Rainfall in mm at					
Month	O'Okiep (av. 72y.)	Springbok (av. 83y.)	HMNR 1974	O'Okiep 1974	Springbok 1974
JAN	4,2 (1)	3,9 (1)	14,5	33,6 (5)	21,5 (3)
FEB	7,8 (1)	8,5 (1)	10,0	13,6 (5)	12,5 (3)
MAR	9,9 (3)	13,1 (2)	55,5	16,1 (3)	10,0 (2)
APR	13,8 (3)	17,8 (3)	4,6	9,9 (4)	6,5 (2)
MAY	24,3 (4)	32,7 (4)	2,4	13,1 (3)	7,2 (4)
JUN	26,6 (5)	38,0 (4)	28,7	52,5 (10)	41,7 (8)
JUL	19,2 (4)	32,7 (4)	3,2	3,2 (2)	9,1 (3)
AUG	22,8 (5)	32,0 (4)	39,5	70,8 (13)	90,8 (13)
SEP	14,3 (4)	18,7 (3)	1,0	5,5 (5)	3,5 (3)
OCT	8,8 (3)	13,3 (3)	2,9	3,8 (5)	6,8 (3)
NOV	5,7 (2)	7,6 (2)	0,0	0,5 (3)	8,5 (1)
DEC	4,1 (2)	5,6 (2)	0,0	0,1 (1)	0,0 (0)
YEAR	161,5 (38)	223,9 (34)	162,3	231,7 (59)	218,1 (45)

*Unpublished data obtained from the Department of Transport, Forum Building, Struben Street, Pretoria 0002.

The mean weekly percentage relative humidity of the atmosphere at 08h00 and 14h00 for the reserve for the period April to November 1974 is presented in Figure 2. The annual cycle of the relative humidity is of the continental type with the maximum in winter and the minimum in summer.

The weekly average of the daily maximum and minimum temperatures as well as the rainfall for the study site for the period April to November 1974 are presented in Figure 3. Attention is drawn to the fact that the rainy season and the coldest period of the year coincide. During this period it will probably be the low temperatures rather than a water shortage that will limit plant growth. Frost commonly occurs during the winter months but no frost injury to the plants was observed.

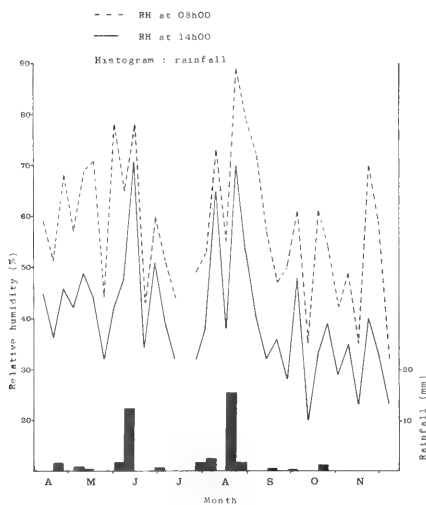


FIG. 2.

Mean weekly percentage relative humidity of the atmosphere at 08h00 and 14h00, as well as the weekly rainfall of the Hester Malan Nature Reserve from April to November 1974.

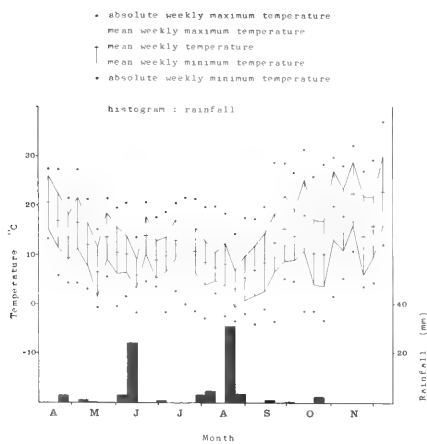


FIG. 3.

Absolute and mean weekly air temperatures and rainfall of the Hester Malan Nature Reserve from April to November 1974.

According to Acocks (1975) the study area lies within the Namaqualand Broken Veld and borders on the False Succulent Karoo. Physiognomically the vegetation has a decided chamaephytic character (Rösch, 1977). Many of the dwarf shrubs exhibit xeromorphic characteristics by being deciduous, microphyllous, aphyllous and/or succulent. A large percentage of the species are therophytes that are especially conspicuous during the spring of a good rainy season.

METHODS

Phenological data were collected for 116 species at fortnightly intervals from April to November during 1974. Instead of repeatedly investigating specific individuals of the species, the general condition of plants scattered throughout the reserve was noted. At any observation date a species was regarded to be in a particular phenological stage only if at least 10 % of the plants of the species were in that phenological stage.

The following developmental stages were recorded:

vegetative growth: production of leaves and/or existing leaves not senescent;

production of floral buds: unopened flower buds present on plants;

flowering: flowers at anthesis on plants;

fruit development: developing fruit present on plants; and

mature fruit: mature fruit present on plants.

The species investigated were grouped into five different life-form categories according to the revision of the Raunkiaer plant life forms by Müller-Dombois and Ellenberg (1974).

A principal components analysis (Seal, 1968) was carried out on the phenological data of the 116 species that were investigated.

RESULTS AND DISCUSSION

Among the investigated species 44 were therophytes, 24 geophytes, 8 hemicryptophytes (H), 29 chamaephytes (Ch) and 7 were phanerophytes (P). The phenological diagrams of the therophytes, geophytes and phanerophytes, chamaephytes and hemicryptophytes are presented in Figures 4, 5 and 6 respectively. Within each figure the species are arranged according to the time of onset of flowering.

General observations over a number of years reveal that although the various phenological stages regularly occur in the same sequence, the exact times of the various stages vary somewhat from year to year.

In Namaqualand a year can be divided into four fairly well defined phenological periods, *viz.*:

- a. a mild, relatively moist autumn, during March, April and early May;
- b. a cold, moist winter during late May, June and July;

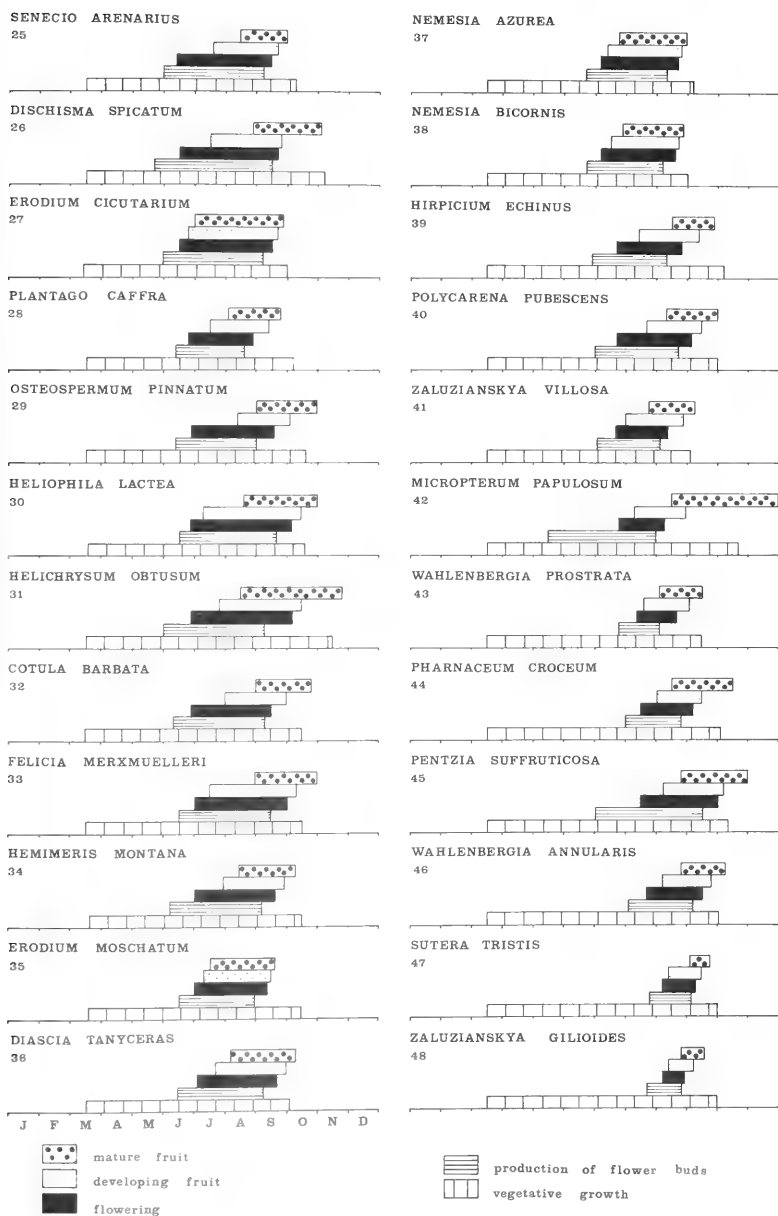


FIG. 4.

Phenodiagrams of selected therophytes in the Hester Malan Nature Reserve.

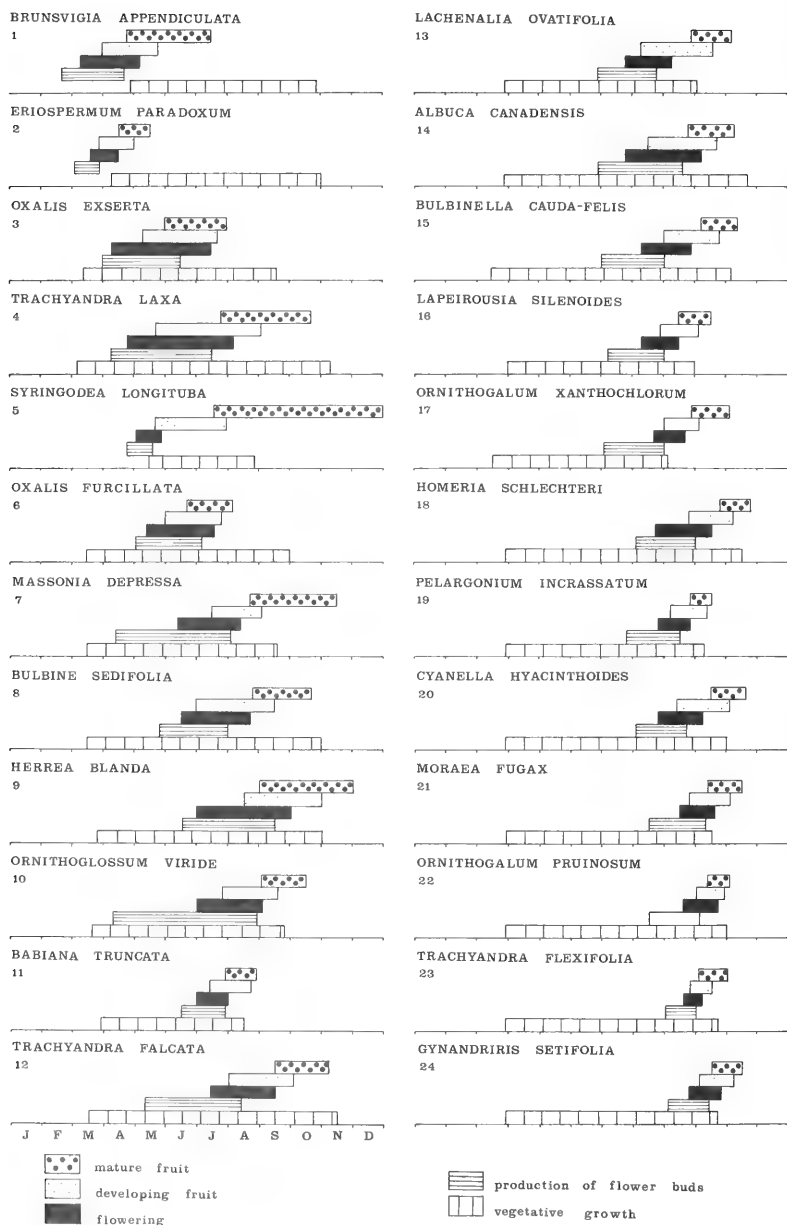


FIG. 5.
Phenodiagrams of selected geophytes in the Hester Malan Nature Reserve.

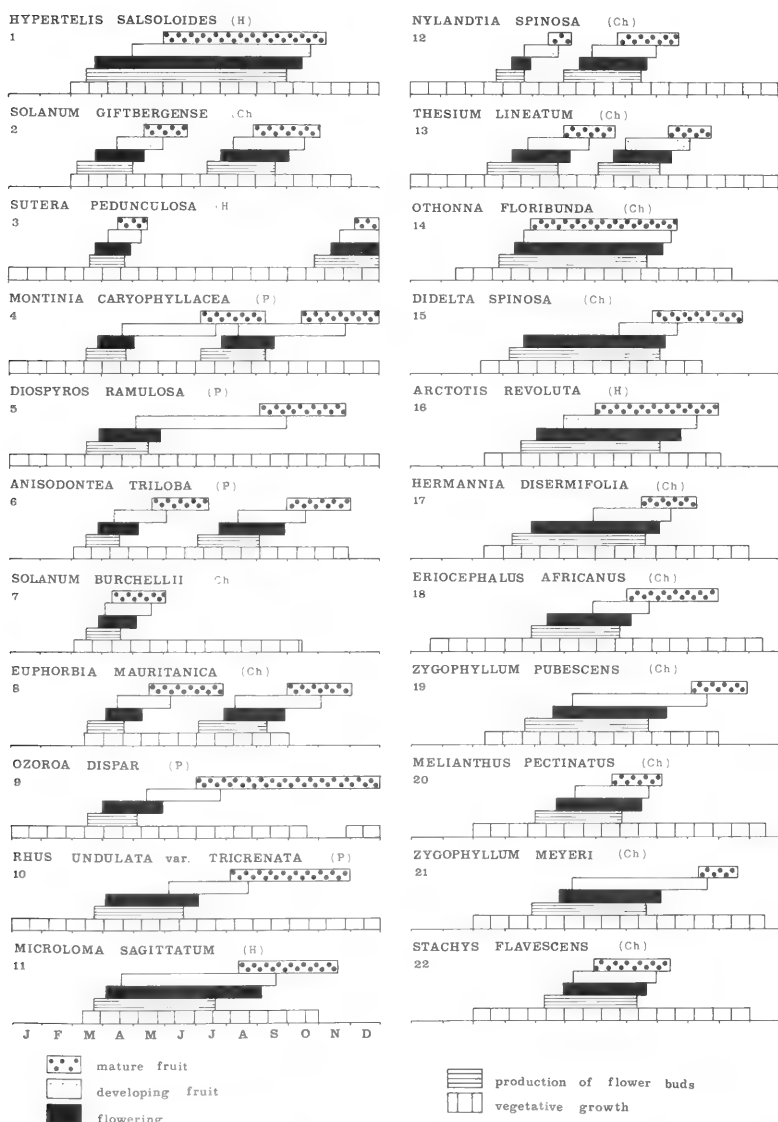


FIG. 6.

Phenodiagrams of selected phanerophytes (P), chamaephytes (Ch) and hemicryptophytes (H) in the Hester Malan Nature Reserve.

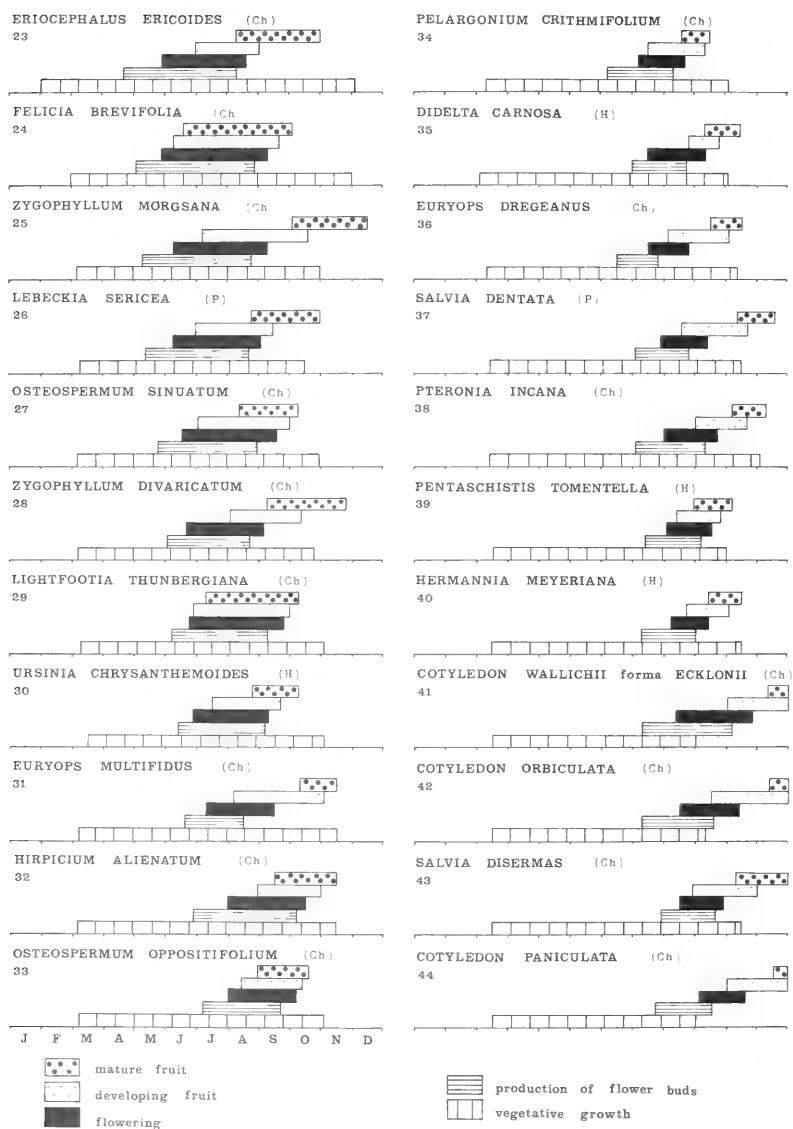


FIG. 6.

Phenodiagrams of selected phanerophytes (P), chamaephytes (Ch) and hemicryptophytes (H) in the Hester Malan Nature Reserve.

- c. a mild, relatively moist spring during August, September and early October; and
- d. a hot, dry summer from late in October to the end of February.

The growing season generally starts in autumn or late summer following good rains and a drop in the prevailing temperatures. Between 10 and 13 March 1974 the reserve received 55.5 mm of rain. When the observations were commenced in April, most of the perennial species were growing actively and many of the deciduous species were sprouting. It is possible, however, that some of the deciduous species had already started to sprout after the rains in February. Only a few perennial species, such as *Solanum* species (Ch), *Montinia caryophyllacea* (P), *Diospyros ramulosa* (P), *Ozoroa dispar* (P) and *Rhus undulata* var. *tricrenata* (P) flower in autumn (Figure 6). Seed germination, especially of therophytes, takes place mainly in autumn. Few therophyte species flower in autumn and complete their life cycle before the onset of winter. *Tribulus* species (Figure 4) flower in autumn and complete their life cycle before the onset of winter. These plants, however, originate from seeds which germinate in summer. A few geophytes such as *Brunsvigia appendiculata* and *Eriospermum paradoxum* (Figure 5) also flower in autumn and subsequently produce vegetative leaves.

As the temperature drops further during the winter months, the growth rate of the plants decreases to a very low level, despite the fact that this period is usually the wettest part of the year. For instance, during 1974 the 28.7 mm of rain in June had little obvious effect on the growth rate of the plants. The flowering of many chamaephytic species, such as *Didelta spinosa*, *Hermannia disermifolia* and *Eriocephalus* species (Figure 6) begins in winter. Most therophyte species will not attain their peak flowering stage during winter. Under unfavourable growing conditions the therophytes may however produce a small number of flowers during winter, as happened in 1974 when the early winter was relatively dry and the plants were quite depauperate.

Flowering occurs mainly in spring, after the temperature has risen, but before drought conditions set in. In 1974, hardly any rain fell from mid-June to mid-August and by the end of this long dry period it seemed as though most of the therophytes were on the verge of dying. A good rain at this stage stimulated the plants into active growth and flowering; and by early September the flowering of the therophytes had reached its peak. Many of the perennial shrubs, such as *Osteospermum sinuatum* (Ch) (Figure 6) which had started to flower in winter, produced a large number of additional flowers at this stage, thus covering the entire plants.

Phenologically, spring can possibly be subdivided into a prevernal (early spring) and vernal (late spring) aspect. The well-known flowering season of Namaqualand constitutes the prevernal aspect when a large percentage of the therophyte species, such as *Ursinia* species, *Osteospermum* species, *Heliophila*

species, *Arctotis* species, *Arctotheca calendula*, *Pentzia* species, *Dimorphotheca* species, *Cotula* species, *Nemesia* species and *Gazania* species (Figure 4) are in full bloom. Perennial species of *Osteospermum* (Ch), *Felicia* (Ch) and *Lebeckia* (P) are also quite conspicuous during this period (Figure 6). During late spring (the vernal aspect), it is mainly geophytes (Figure 5), such as *Albucca* species, *Ornithogalum* species, *Homeria* species, *Moraea* species and *Gynandris* species as well as a number of the Mesembryanthemaceae, such as *Drosanthemum* species, *Leipoldtia* species and *Ruschia* species that reach their flowering peak. Shrubs which flower late in spring are, amongst others, *Hirpicium alienatum* (Ch), *Berkheya* species (Ch), and *Salvia dentata* (P) (Figure 6). A few shrubby species such as *Montinia caryophyllacea* (P) and *Anisodonteia triloba* (P) flowered during both the autumn and spring of 1974. Other important phenological processes which take place during spring are the ripening and dispersal of fruit and seed, especially of the therophyte species.

Phenologically the summer begins when the deciduous species start shedding their leaves. Very few species flower during this time of the year and those that do, such as *Cotyledon* species and *Gethyllis* species, have by then usually completed their vegetative growth for the season. Many fruits and seeds, especially of the perennial species ripen during summer. A few species, such as *Othonna furcata*, flower towards the end of summer before any vegetative leaves have been produced.

Active plant growth is therefore limited mainly to autumn and spring, when both temperature and moisture conditions are favourable for plant growth. During winter the low temperatures possibly inhibit growth, whereas the combined effects of high temperatures and water deficiency during summer possibly preclude plant growth. This annual growth pattern is very similar to that which is found in regions with a Mediterranean climate (Mooney & Dunn, 1970; Mooney, Parsons & Kummerow, 1974).

The phenological spectrum of the species comprising a community or veld type often provides a good insight into the relations between the different life form groups. In the case of the Hester Malan Nature Reserve it was found that the annual growing season of the therophytes comes to an end first. Thereafter most of the shrubs and geophytes become dormant until finally the succulents cease to grow. This statement is supported by a principal components analysis of the phenological data collected on the reserve in 1974. Results (Figure 7) show that the phenological patterns of the therophytes, perennial shrubs (phanerophytes, chamaephytes and hemicryptophytes) and geophytes differ.

The flowering periods of plant species can be used as a basis for speculating about their affinities to other vegetation types. Species that flower in winter can possibly be regarded as having affinities to the Cape Flora, which also lies in a winter rainfall region. On the other hand, species that flower in summer probably have a northern and/or eastern origin.

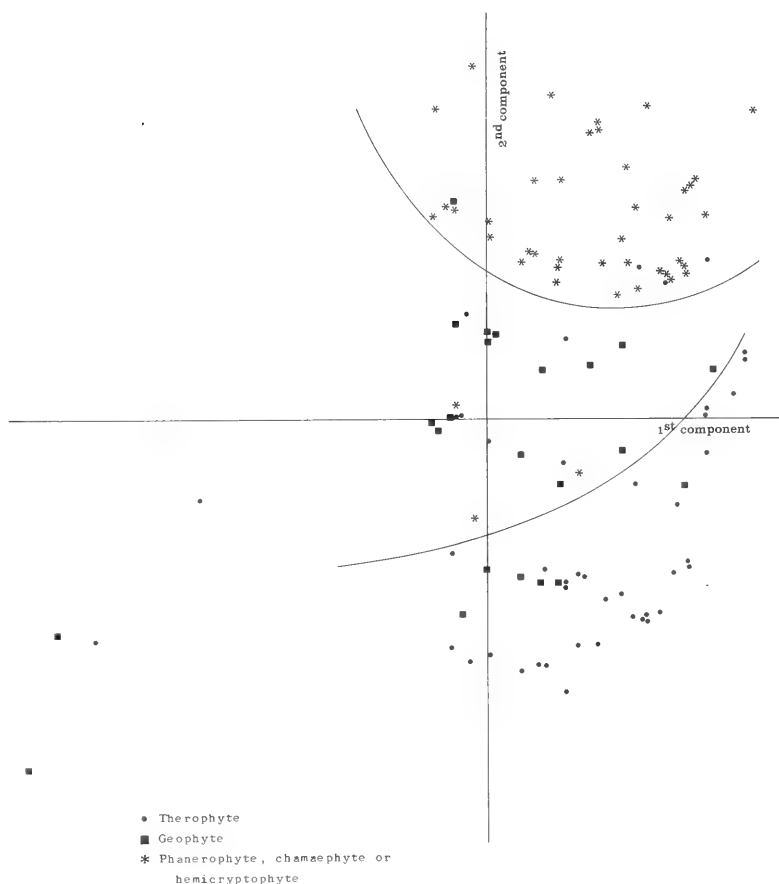


FIG. 7.

A scatter diagram of the life forms as determined by the first two components of a principal components analysis of the phenological data of selected species in the Hester Malan Nature Reserve.

The control of the phenological development of plants is probably very complex. In some cases temperature is thought to be of overriding importance, but in other cases moisture, day length and temperature are probably equally important and interact strongly in regulating the development of plants (Ratcliffe, 1961; Zohary, 1962; Ackerman and Bamberg, 1974; Taylor, 1974; Davies, 1976). Zohary (1962) claims that the flowering season of many species is not determined

by the environment in which the plants are currently growing, but is controlled by endogenous factors, such as a phenological rhythm which was induced by the environment from which the species migrated.

SUMMARY

The study was conducted in the Hester Malan Nature Reserve which is situated in the Namaqualand Broken Veld. The climate of the study area is best described as a hot and dry desert climate characterized by sparse and erratic rainfall and considerable daily and seasonal temperature fluctuations. The phenology of the species occurring in this region is closely related to the climate.

Even though some of the perennial species had already started to sprout by the end of summer, the beginning of the rains in autumn was regarded as the start of the growing season. Germination of therophyte seeds occurs mainly after these autumn rains. Growth during the winter months is slow, despite the adequate available moisture, possibly as a result of low temperatures. A number of perennial plant species normally flower during winter but many therophyte species will also produce some flowers in winter if conditions are unfavourable for vegetative growth. The main flowering period of most of the annual as well as perennial species is in spring and by the end of this season there are a large number of species which disperse their diaspores. The summer phenological aspect begins when the perennial plant species lose their leaves and become dormant. Very few plant species flower during summer and the most noteworthy phenological phenomenon during this period is diaspore dispersal.

ACKNOWLEDGEMENTS

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THE AFRICAN GENUS *FERRARIA*

MIRIAM P. DE VOS

(Department of Botany, University of Stellenbosch)

ABSTRACT

Herbarium material and living plants from their natural habitats were studied for this revision of *Ferraria*, a genus principally concentrated in the winter rainfall region of the Republic of South Africa, with one species widely distributed in Central Africa south of the equator. In order to supplement the morphological diagnostic characters, the leaf anatomy and karyotypes of the species were also investigated.

The genus is subdivided into three sections and ten species are recognised, two of which are new species, namely *F. densepunctulata* and *F. kamiesbergensis*. Illustrated descriptions of the species, their geographical distribution, synonymy, and karyotypes are given. Two polymorphic species occur and are divided into subspecies. Most species are diploid with $2n = 20$; three are heteroploid with $2n = 20$ and 40 , and $2n = 40$ and 60 .

UITTREKSEL

DIE AFRIKA-GENUS *FERRARIA* (IRIDACEAE)

Herbariummateriaal en lewende plante uit hul natuurlike habitats is ondersoek vir hierdie hersiening van *Ferraria*, 'n genus wat hoofsaaklik in die winterreënstreek van die Republiek van Suid-Afrika voorkom, met een spesie wydversprei in Sentraal-Afrika suid van die ewenaar. Behalwe die morfologiese diagnostiese kenmerke, is die blaaranatomie en die kariatipes van die spesies ook ondersoek.

Die genus word in drie seksies ingedeel en tien spesies word erken, waarvan twee nuwe spesies is, t.w. *F. densepunctulata* en *F. kamiesbergensis*. Geïllustreerde beskrywings, die geografiese verspreiding, sinonimie, en die kariatipes van die spesies word aangegee. Twee polimorfe spesies kom voor en word in subspesies ingedeel. Meeste spesies is diploïed met $2n = 20$ chromosome; drie is heteroploïed met $2n = 20$ en 40 , en $2n = 40$ en 60 .

INTRODUCTION

Ferraria is a small African genus of the Iridaceae, tribe Irideae, comprising ten species, with the greatest concentration of species in the western coastal districts of the Cape Province of the Republic of South Africa (R.S.A.). The genus was named by Johannes Burman in honour of Giovanni Battista Ferrari who first described and figured a *Ferraria* in 1633, under the descriptive title *Flos indicus e violaceo fuscus radice tuberosa*. He believed it to come from Batavia.

From the time that Ferrarias were introduced to Europe they attracted interest on account of their unusual flowers having remarkable colour combinations and styles with erect tufts of hair-like processes.

The genus is in need of revision. The last comprehensive treatment of the genus is by Baker (1896) in the *Flora Capensis*, who recognised only six species. After this date several new species have been described.

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Some 50 *Ferraria* binomials are listed in the *Index Kewensis*. Of these 20 have been transferred to various genera, leaving some 30 binomials for the African *Ferraria* species. Nine of these have already been recognised as synonyms, but the remaining binomials are still far in excess of the true number of known *Ferraria* species.

The present revision of the genus is based on external morphological, anatomical and cytological studies. Herbarium material, including the types of the majority of specific names, as well as fresh material collected over the whole geographical range of the genus, has been used for this investigation. Results based on chemotaxonomic research work proved inconclusive, as the supply of seed needed for this type of investigation was inadequate.

MORPHOLOGY

Habit Ferrarias are small to medium sized herbaceous deciduous geophytes varying in height from ca. 70 mm to almost one metre. The plant has an underground stem comprising a row or group of persisting perennial corms to which a new corm is added annually.

The South African species are adapted to winter rainfall conditions. At the beginning of the rainy season (March to May) a bud near the top of the youngest corm, or sometimes one on an older corm, gives rise to adventitious roots and then to a shoot which may flower in winter, spring or early summer (May to November), depending on the species. The base of this shoot gradually becomes swollen with food materials and forms a new corm. After the ripening of the seeds from September to December, the shoot withers.

The only species adapted to summer rains is *F. glutinosa* which occurs in regions north of the Republic. This species puts out a shoot after the spring or summer rains have started, and flowers in summer, usually between November and March.

Roots At the beginning of the growing season up to eight adventitious roots are formed around the base of the developing bud. After development of the new corm these roots are attached to the narrow neck connecting the new corm to the old one. Additional roots are formed from the top internode of the new corm and break through the enveloping cataphyll (Fig. 2).

Should the new corm come to lie too close to the surface of the soil, a thick contractile root develops from its top internode or from the base of the developing shoot, pulling the new corm deeper down and sometimes snapping its connection to the older corm.

Subterranean stem (Figs 1, 2) The underground stems are generally referred to as persisting corms. Lewis (1954, p. 72) considered this stem to be a "tuberous corm . . . which probably represents a transition stage from a rhizome to the type

of corm . . . (found) in many genera of the Iridoideae, such as *Hexaglottis*, *Moraea*, etc. (and which) differs from all others in the family in having no persistent scale leaves or tunics, and is actually more in the nature of a tuber''.

The mature corm is covered with a brown cuticle ca. 5 μm thick comprising two fused layers, the inner being the cuticle of the corm epidermis, and the outer that of the adaxial epidermis of the sheathing cataphyll initially covering the developing corm (Fig. 2). In the older corm this cuticle is the only part of the sheathing cataphyll(s) that is left. Remains of vascular bundles and adaxial epidermal cells impregnated with tannin, are still present in younger corms. This epidermis remains meristematic for a longer period than other tissues of the cataphyll, dilating with the corm and keeping it covered for some time.

As part of the cataphyll, albeit very thin, still remains, I shall continue to use the term *corm* for the subterranean stem of *Ferraria*.

Nowhere is the corm surface covered with cuticles of more than one cataphyll. The adaxial epidermis of the lowest cataphyll which is attached to the base of the corm, covers and fuses with the surface of the large basal internode of the corm. At the second node the upper part of this cataphyll withers completely and disappears. Here the adaxial epidermis of the second cataphyll fuses with the second internode of the corm (if such is present). Above the third node, if present, the epidermis of the third cataphyll is the only persistent cover of this region.

Dry corms that have not yet sprouted are able to absorb a little water at the beginning of the rainy season. Their water absorbing capacity varies from about 1% to 3% of the corm's mass.

The annual development of a new corm and the perennial nature of the older corms result in the formation of a row of corms (Fig. 1) which may be arranged vertically or, in the case of *F. ferrariola*, obliquely or almost horizontally. The corms are connected to each other by a narrow neck in which several vascular strands converge and which later becomes somewhat suberised.

The corm comprises one to several internodes. Its bulk is formed by the basal internode of the shoot, and in species with large corms, e.g. *F. divaricata*, *F. crispa* and *F. foliosa*, by two to three internodes. The upper internodes are short. The nodes are evident on the corm surface as fine circular lines.

Internally the corm is composed of a hard horny storage tissue of colourless parenchyma consisting of more or less isodiametric cells packed with large and small, simple starch grains. Oil globules occur in the epidermis and subepidermal layers. The epidermis has a thick outer cellulosic cell wall ca. 10 μm wide below the cuticle, and elongated pits in the anticlinal walls. The cell walls of the ground tissue are 4–5 μm wide and are pitted. Vascular bundles spread throughout the corm and converge towards the base and top. A distinct central stele is absent. The xylem comprises mostly annular, spiral and scalariform vessels. Large styloids occur singly in narrow elongated idioblasts, interspersed among the storage cells and concentrated towards the base of the corm.

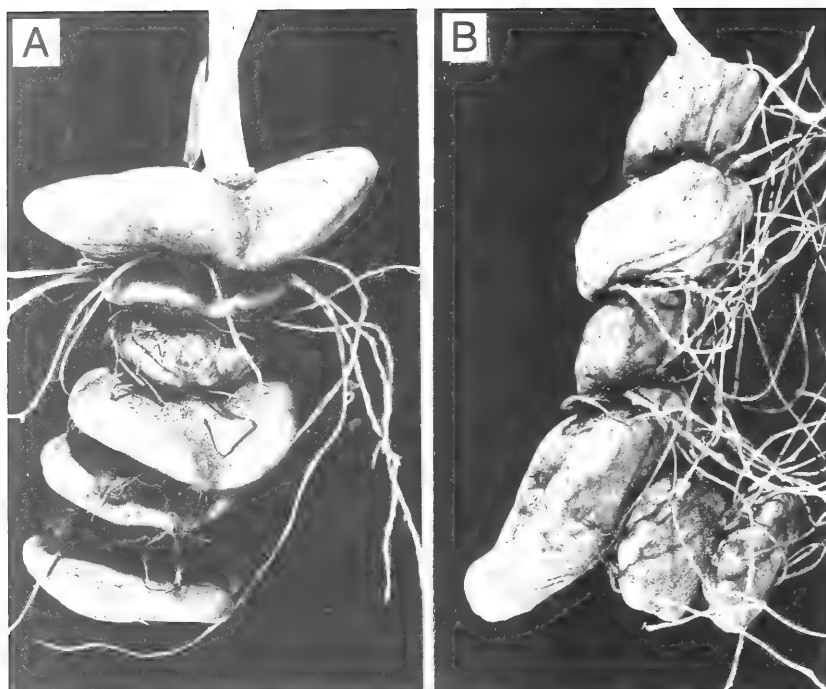


FIG. 1.
Corms of A, *Ferraria uncinata* and B, *F. ferrariola*. $\times 1,2$

F. crispa and *F. foliosa* sometimes form offshoots in the form of underground stolons, from a bud near the top of a young corm. In sandy ground the stolon may attain a length of 100 mm, giving rise at its tip to a young corm from which a shoot will develop in the following year.

Shortly after the start of the cultivation of *Ferrarias* in England, it was found that corms may rest for longer than a year without sprouting, even under favourable conditions. Miller (1759a) remarked: "There is great singularity in the Root of this Plant: For it does not vegetate annually, as most others do; but, on the contrary, lies inactive every other Year; and sometimes it will remain two Years without putting out either Leaves or Fibres; and during that time it will be perfectly sound and fair." Andrews (1803) also drew attention to this interesting feature.

Resting periods of more than a year have now again been observed under horticultural conditions, in several species such as *F. uncinata* and *F. divaricata*; but they do not occur as regularly as observed by Miller. This phenomenon

The African genus *Ferraria*

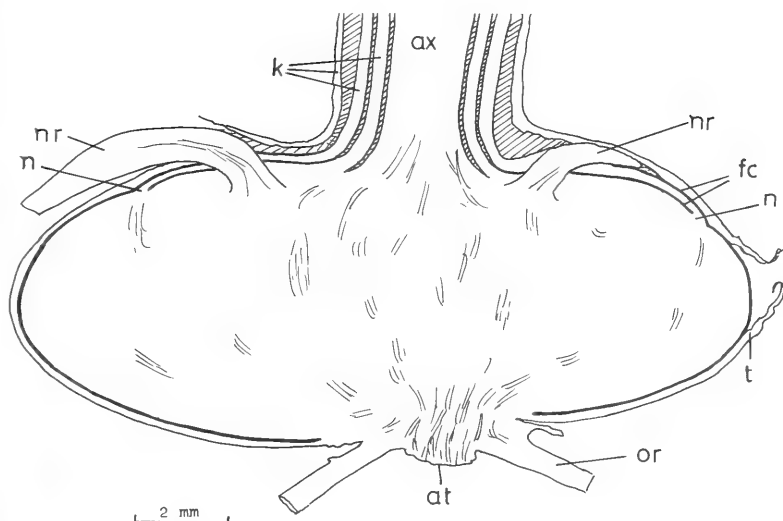


FIG. 2.

Median longitudinal section through young corm of *Ferraria divaricata*: at, attachment to older corm; ax, aerial axis; fc, fused cuticles of tunics and corm epidermis; k, cataphylls, the bases of which form the tunics; n, node; nr, new root emerging; or, old root of previous season; t, disintegrating tunic.

probably also occurs in their natural habitats. It may be an adaptation to drought conditions, a feature which often occurs in the habitats of these plants.

The corms are asymmetrical or almost symmetrical, depressed globose, conoidal, obliquely ovoid, or irregular in shape (Fig. 1). They have, however, little diagnostic value, as variation in size and shape occurs within single species, e.g. in *F. foliosa* they are depressed globose to conoidal, the size and shape depending on the age of the plant, and also to some extent on environmental conditions such as soil texture and available moisture. The size varies from ca. 10 to 35 mm in diameter and rarely, e.g. in *F. foliosa* and *F. schaeferi*, to 50 mm or 60 mm. The corms in the group often range from small older corms to larger new ones, the size being proportional to the size of the shoot, which again depends on the age of the plant and prevailing environmental conditions. Occasionally a small corm occurs between two larger ones, indicating an unfavourable growing season.

The corm of *Ferraria* corresponds with that of *Hexaglottis*, *Homeria*, *Gynandris* and *Moraea* of the tribe Irideae in lacking a distinct central stele and in most of its roots emerging from the upper part of the corm. It differs in several respects: in being perennial and almost naked; in often consisting of more than one internode; in being formed from the basal internode(s) of the aerial axis. (The

corm of *Hexaglottis*, etc. is formed by an axillary bud, the aerial axis dying down completely at the end of each growing season, f. De Vos, 1977; Lewis, 1954). In the above-mentioned features it resembles the *Watsonia* type of corm of the tribe Ixieae (De Vos, 1977), but differs in being almost naked and perennial, and in lacking a central stele.

The *Ferraria* corm is indeed an intermediate stage, as Lewis (1954) already stated, between the rhizome of genera such as *Bobartia* and *Dietes*, and the tunicated annual corms of *Homeria*, *Hexaglottis*, *Gynandriris* and *Moraea*.

Aerial axis A shoot usually develops from the top axillary bud on the corm of the previous year. This bud is often situated somewhat above the node. In young plants that have not yet flowered, the apical bud of the corm forms the new shoot. Large corms with several internodes, such as *F. foliosa* and *F. divaricata*, may form shoots over several years, at first from axillary buds and later, when these have been depleted, from adventitious buds which develop and sprout. This can result in a branching of the corm group.

The aerial stem is from 50 mm to almost 1 m in length and consists of few to numerous internodes. It is laxly or more often densely and repeatedly branched in its upper part to form a small to large corymbose inflorescence. In most species it is densely covered with foliage leaves, exceptions being *F. glutinosa*, *F. ferrariola* and *F. densepunctulata*. In the former a viscid zone occurs below each node and the leaf bases sheathe only a small portion of the long slender internodes. In the last-mentioned two species the stem is short and compact, the leaf bases sheathing the greater part of each internode.

Leaves The leaves are generally equitant and in distichous sequence, but in *F. foliosa* and in the upper parts of larger plants of *F. crispa* and *F. schaeferi* they are spirodistichously twisted.

One to three cataphylls occur at the base of the shoot, attached to nodes below and on the developing corm. They are 15 to 120 mm, and rarely to 200 mm long, and consist of bifacial sheathing leaf bases only. In its lower half the two margins of a cataphyll are fused to form a cylindrical sheath around the corm and base of the shoot. The top of the upper cataphyll appears above-ground and is green and, in some species, spotted or mottled purplish-red. Irregular purplish-red spots are distinctive in *F. ferrariola* and help in identifying this species.

The foliage leaves are few to numerous and are cauline, developing from nodes on the aerial stem above the corm. They consist of large bifacial amplexicaul leaf sheaths and long or short, unifacial blades which are firm in texture, often glaucous and somewhat xeromorphic. The blades are usually narrowly ensiform to linear and sometimes swollen in their median zone (e.g. *F. crispa*, *F. schaeferi*), or compressed cylindrical (*F. ferrariola*, *F. densepunctulata*). *F. brevifolia* has distinctive short, obliquely ovate leaf blades which are much shorter than the leaf sheaths. In *F. foliosa* the unifacial parts of the leaves are also short compared with the large bifacial sheaths.

The leaf margins are cartilaginous, firm and often pale green or yellowish green in colour. They are smooth, except in *F. uncinata* where at least some leaves have finely crisped margins. In some species, such as *F. brevifolia*, the margins are strongly thickened; in others, e.g. *F. densepunctulata*, the marginal thickening is almost indistinguishable in fresh material. The leaf tip is obtuse to acute and often incurved; this feature varies within most species.

Young plants, not having yet reached the flowering stage, possess one or two long, very narrow, unifacial leaves, which are often rhomboidal or sometimes almost cylindrical in cross section (e.g. *F. foliosa*, *F. crispa*, *F. densepunctulata*). They have at their bases a much reduced, closed leaf sheath which covers the abbreviated axis.

Leaf anatomy. Anatomically the leaves of the species of *Ferraria* differ only in minor details, such as in the amount of colourless mesophyll, the position of the veins, and the presence of epidermal papillae (Fig. 3).

The epidermal cells are somewhat dome-shaped in transverse section, mostly 30–40 μm in height; in costal areas of *F. schaeferi* and *F. densepunctulata*, however, they are up to 70 μm high. The outer cell walls comprise a thick cellulosic layer of 4–8 μm (up to 12 μm in *F. schaeferi*), covered with a thin cuticle only ca. 1 μm in thickness.

In several species of section *Macroscyphae* each epidermal cell has a centrally placed papilla on its surface, formed by a small evagination of the outer cell wall. These papillae are 18–20 μm in diameter and vary in height from ca. 10 μm in *F. brevifolia* and *F. kamiesbergensis* (which is occasionally without papillae) to ca. 20 μm in *F. uncinata*. In subspecies *macrochlamys* of the latter species papillae on the costal areas are elongated into one-celled trichomes 60–80(–100) μm long. The cell lumen and cytoplasm of the epidermal cell extend up into each hair. In section *Ferraria* only *F. schaeferi* occasionally possesses papillae. Here each papilla occupies the width of an epidermal cell, being 40–45 μm in diameter and to 10 μm in height; they appear to be solid thickenings of the outer cellulosic cell wall, covered with the thin cuticle.

Stomata are confined to intercostal areas where they alternate regularly with elongated epidermal cells. They are sunken and lack subsidiary cells. The guard cells are usually 30–40 μm long, but in the hexaploid *F. crispa* they measure to 50 or 60 μm .

The mesophyll comprises three or four layers of palisade tissue below the epidermis on each side, and a central colourless parenchymatous tissue of large thin-walled water storing cells with minute intercellular spaces. A spongy layer is lacking. In section *Ferraria*, as well as in *F. ferrariola*, this layer is swollen in the median zone storing a larger amount of water. As the habitat of these species is the dry sandy regions of the west coastal belt, they are probably often in need of a water reserve.

Both margins of the leaf blade are furnished with a strong bundle of

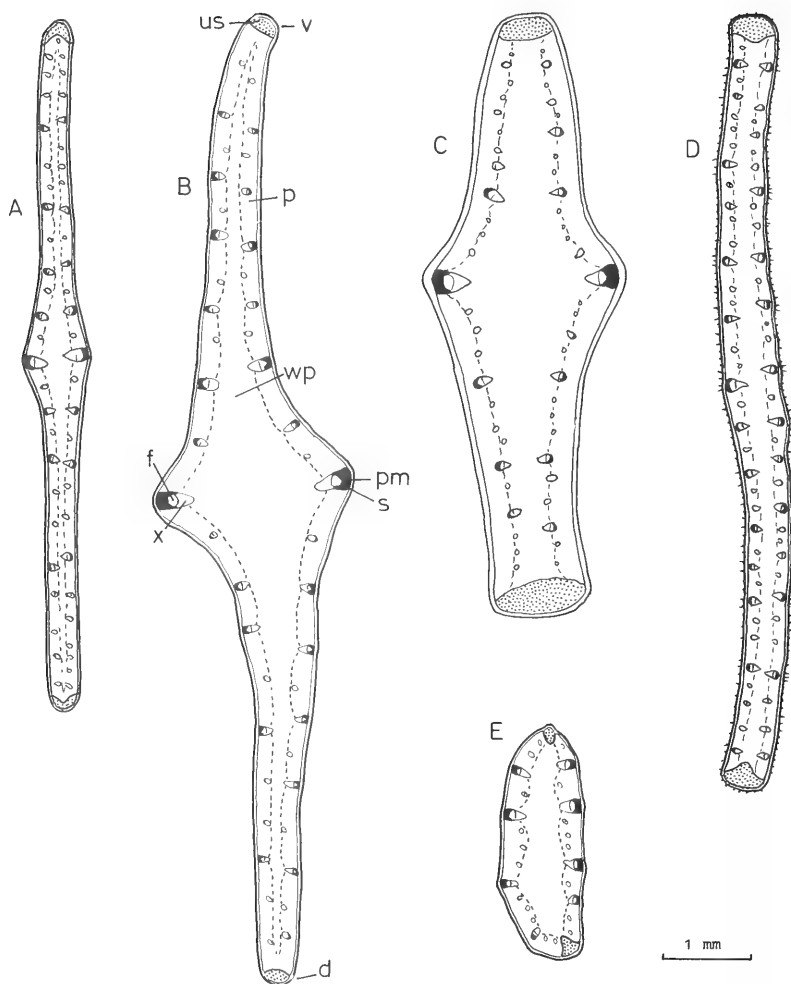


FIG. 3.

Transverse sections of leaves of *Ferraria* species, taken about halfway up the leaf blade. A, *F. glutinosa*; B, *F. crista*; C, *F. schaeferi*; D, *F. uncinata*; E, *F. ferrariola*; d, dorsal margin of unifacial leaf blade; f, phloem; p, palisade chlorenchyma; pm, "pseudo" midrib; s, sclerenchyma; us, unlignified marginal sclerenchyma; v, ventral margin of unifacial leaf blade; wp, colourless waterstoring parenchyma; x, xylem.

unlignified fibres, each fibre about 1 mm in length and 7–10 μm in diameter, with tapering ends and thickened cellulosic walls. The dorsal margin of the unifacial leaf blade represents the midrib of the bifacial leaf sheath but lacks a large vein; the ventral margin represents the two "fused" margins of the sheath. The crisped leaf margins of *F. uncinata* are due to an excessive elongation of the marginal fibres.

Tannin containing idioblasts occur in the colourless parenchyma in the neighbourhood of veins in *F. glutinosa* and *F. ferrariola*.

Two larger veins, forming a pseudo-midrib, occur in leaves of *F. glutinosa*, *F. ferrariola*, and species of section *Ferraria*. They lie more or less opposite each other on either side of the colourless parenchyma tissue (Fig. 3A, B, C). Every large and medium sized vein has a bundle of lignified fibres against the phloem. In most species of section *Macroscyphae*, as well as in *F. densepunctulata* of section *Ferraria*, a single layer of parenchyma, which is part of the bundle sheath, occurs between the sclerenchyma and the epidermis. In three species of Section *Ferraria*, as well as in *F. ferrariola*, the sclerenchyma of the larger veins lies against the epidermis.

Numerous styloids, typical of the Iridaceae, occur in subepidermal longitudinal rows in the costal zones. They lie singly in narrow elongated idioblasts, and are 50–120 μm long and 8–18 μm wide, and square, or sometimes rectangular, in cross section.

The phloem is composed of a few sieve tubes with companion cells, except in *F. glutinosa* where in addition some phloem fibres occur in large veins. The xylem comprises annular, spiral, and pitted vessels with transverse pits, embedded in a small mass of xylem parenchyma. The vessels of the large bundles vary greatly in size and are up to 50 μm in diameter. Anastomosing bundles between the parallel veins are small and infrequent.

The leaf anatomy indicates a close relationship between *F. uncinata*, *F. brevifolia* and *F. kamiesbergensis*, and also between *F. crispa*, *F. foliosa* and *F. schaeferi*. It further shows that *F. ferrariola* is intermediate between sections *Ferraria* and *Macroscyphae*; and that *F. glutinosa* shows a closer affinity to section *Ferraria* than to section *Macroscyphae*.

Inflorescence The branched upper part of the aerial axis constitutes a dense, or rarely lax, corymbose inflorescence composed of few to numerous suberect, cylindrical cymes. These are borne at the ends of the branches and branchlets, subtended by the short bract-like upper leaves. Each cyme generally contains two flowers enclosed in two large, green, opposed bracts or spathes. As an exception three flowers may be present, and in *F. glutinosa* up to six flowers per cyme are normally produced.

The two spathes are firm in texture and imbricate, both encircling the flowers completely. They show numerous parallel veins, pale or sometimes reddish membranous margins, and are often keeled, with their tips somewhat hooded. The

outer spathe is generally ovate and always shorter than the inner which is lanceolate and (30–)40–70(–90) mm long. Between the two flowers in the cyme a single semi-hyaline, shortly lanceolate bracteole (prophyll) is present, ca. 20–30(–50) mm in length. It envelops the younger flower while still in the bud, and is placed with its dorsal side against the older flower.

The basal internodes of most axillary branches are much reduced, so that two cymes are often congested in the axil of a single bract-like foliage leaf. The cyme nearer the subtending leaf represents the primary axillary branch and the other, nearer the main axis, a secondary branch. The latter is in the axil of the first leaf of the primary branch, which is in the form of a prophyll addorsed to the main axis.

Flowers open consecutively, but in large plants flowers from more than one cyme may be open simultaneously. The terminal flower is the first to open, followed by the terminal flower on the lowest axillary branch. The third flower to open may be either the second flower of the top cyme or a flower on the second axillary branch. Flowering continues for several weeks in the case of large plants of *F. crispa*, *F. foliosa* and *F. schaeferi*, while the inflorescence progressively enlarges by further branching.

At anthesis the perianth, stamens and style branches are exerted, usually from one side of the cyme near its top; the ovary remains sheathed by the spathes till the ripening of the capsule, except in *F. glutinosa* where the small ovary is already exerted at the flowering stage.

Flower The regular flowers are erect or suberect, on pedicels ca. 15–20 mm in length. They vary in length from (30–)35 to 60(–80) mm and in diameter from ca. 35 to 60 mm. They are mostly short-lived, anthesis lasting less than a day in species of sections *Glutinosa*e and *Ferraria*, except for *F. densepunctulata* whose flowers remain open for two days. In section *Macroscyphae* the flowers of most species remain open for two days, but in three species variation occurs: flowers of *F. uncinata* and *F. ferrariola* remain open for two to three days, while those of *F. divaricata* stay open for one to three days.

The flowers of most species emit a scent. *F. foliosa* has an unpleasant mouldy, and *F. crispa* a very unpleasant putrid odour. Both attract flies. The scent of *F. divaricata* too is usually strong and rather unpleasant and has been described by Ker (1804) as not unlike that of fresh olives. Some species, e.g. *F. brevifolia*, *F. kamiesbergensis* and *F. schaeferi*, are sweetly scented.

Nectaries As in other genera of the tribe Irideae, the nectaries of *Ferraria* are superficial on the adaxial side of the claws, at or near their bases. Those on the inner claws generally lie in a median adaxial groove. The abundant nectar exuded lies exposed on the surfaces of the nectaries.

The size and position of the nectaries are specific for most species of *Ferraria*; but unfortunately they are hardly discernible in herbarium specimens. In section *Ferraria* the nectaries are bilobed or sometimes trilobed, often shallowly concave, ca. 2–4 × 3–6 mm in size (often wider than long), and usually

occupy a large part of the lower half of each claw. They are placed from one to a few mm above the claw bases (up to 7 mm above the bases in *F. densepunctulata*). In section *Glutinosae* the nectaries lie 2–5 mm above the claw bases, but in most species of section *Macroscyphae* they are basal or almost basal, usually minute and sometimes hardly discernible even when fresh. An exception is *F. divaricata* which has larger nectaries, those on the inner claws often being a few millimetres above the claw bases.

Pollination is mainly brought about by short-tongued insects like flies, blue bottles, and small beetles which are attracted by the scent and copious amounts of nectar. Pollination of *F. undulata* has been described by Scott Elliot (1891), who named three species of flies attracted to the flowers.

Perigone The perianth segments, ca. 25–40(–50) mm long and 5–10(–20) mm wide, are free and subequal, with the three outer segments somewhat larger than the inner.

The claws are suberect and form a ‘cup’ 8–15(–20) mm deep and 6–15(–20) mm in diameter at the rim. It is widely bell-shaped with a rounded base and often with narrow slits between the claw margins in section *Ferraria*; and narrowly funnel-shaped with a narrow angular base and usually overlapping margins in most species of section *Macroscyphae*. The claws of the outer segments are broader than those of the inner and have thin, almost hyaline margins and a swollen median zone. The margins of the inner claws are swollen, thus forming a median adaxial groove in which the nectaries are situated.

Soon after the opening of the flowers the perianth limbs become strongly reflexed—whence the popular name ‘spinnekopblom’ (spider flower) for several of the species. The limbs have finely or roughly crisped or undulate margins and are generally much longer than the claws, except in two subspecies of *F. divaricata* where they are equal to, or slightly shorter than, the claws. The tips are incurved, acute to acuminate, and, in several species of section *Macroscyphae*, attenuate, tapering to a fine point. With age the tips curl inwards over the style and anthers, thus closing the flower. After closing, some autolysis takes place in the perianth and a drop of liquid forms inside the closed perianth.

A remarkable range of flower colours and colour combinations occurs in the genus. In several species of section *Macroscyphae*, namely *F. brevifolia*, *F. kamiesbergensis* and *F. divaricata* subsp. *aurea*, the colouring is more or less constant, being of a very pale yellow or bright yellow, with the margins of the limbs often a slightly darker yellow or orange-yellow, and the outer segments often dotted with green. A wide variation in colouring occurs in several species: in *F. crispa*, *F. schaeferi* and *F. glutinosa* the colours vary from pale yellow or cream, with dark brown spots and blotches, to the opposite: dark brown, maroon or almost black, often with pale spots and blotches; the crisped margins are greenish or yellowish-brown.

The perianth of *F. uncinata* varies from bright or dark blue or purplish blue

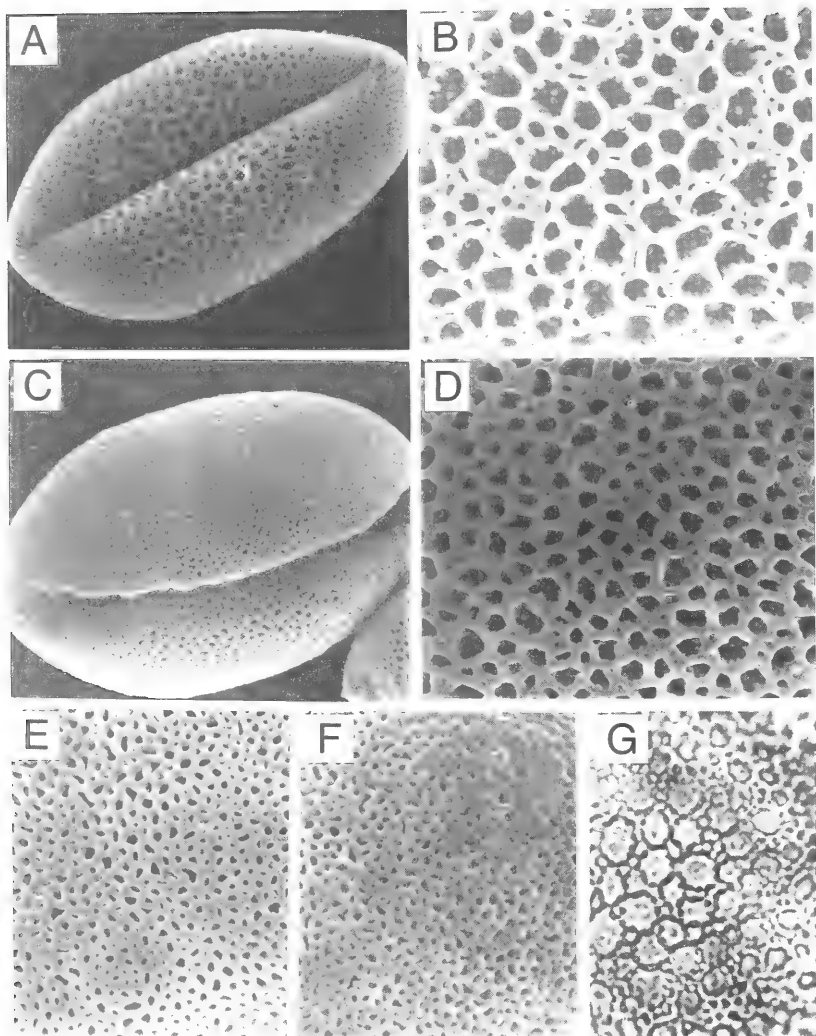


FIG. 4.

Scanning electron micrographs of *Ferraria* pollen. A, B, *F. crispa*; C, D, *F. divaricata*; E, *F. ferrariola*; F, *F. glutinosa*; G, *F. crispa*, light micrograph to show simplibaculate reticulation; A $\times 960$; C $\times 1\ 100$; B, D–G $\times 2\ 600$.

with narrow or wide, greenish yellow margins, to pale yellow in subspecies *macrochlamys*. In *F. ferrariola* the perianth varies from greenish white to pale greenish yellow or pale blue, and the outer segments have distinctive short dark stripes. Flower colours are recorded with RHS numbers (from the colour chart of the Royal Horticultural Society).

Androecium The length of the filaments and style varies with the depth of the perianth cup, thus generally placing the anthers and stigmas above the rim of the cup.

The filaments are inserted at the base of the perianth and are fused to form a slender erect cylindrical tube (6–)8–12(–20) mm in height. They are free at the top for 1–4 mm, where they are slightly flattened and have a shallow adaxial groove. Here they are widely patent, thus placing the anthers in a horizontal or almost horizontal position, appressed to the style branches.

Young anthers of newly opened flowers possess two long parallel thecae 3–6 mm in length. After dehiscing longitudinally, they shrink within three or four hours to about half their original length. The anthers are versatile; in section *Macroscyphae* they are attached above their middle to the filaments and later the two thecae divaricate widely (Figs 5C, D, 6D). In sections *Ferraria* and *Glutinosae* the anther is attached at or just below the middle, and the anther lobes remain parallel (Figs 5A, B, 6B). In *F. ferrariola* divarication of the lobes is slight (Fig. 6F) and occurs later than in the other species of section *Macroscyphae*, so that the anthers of this species seem to vary from parallel to divaricate.

The pollen grains are monocolpate and vary in length from 65 to 106 μm , in the dried condition mounted in Canada balsam. The colpus is slightly shorter than the grain and is edged with a smooth rim ca. 2 μm wide (ca. 3 μm in the hexaploid *F. crispa* and *F. schaeferi*). The grains show a reticulate sculpture (Fig. 4), with muri composed of single rows of pila. In section *Ferraria* the reticulum is strongly heterobrochate (Fig. 4A, B), the brochi (lumina) varying in single grains from 1 μm to 5 or 6 μm in diameter. An almost regular pattern is formed where larger brochi are surrounded by a ring of smaller ones. Towards the two ends of the colpus the brochi are small in *F. crispa* and almost uniform in size. In sections *Macroscyphae* and *Glutinosae* the reticulation is finer (Fig. 4C–F), with brochi more uniform and from less than 1 μm to 3 μm in diameter. The finest sculpturing occurs in *F. ferrariola* and *F. glutinosa* (Fig. 4E, F).

Gynoeceum The ovary is generally slender and (12–)15–40(–60) mm in length. It is somewhat triquetrous and ca. 3 mm in diameter with a narrow base and tip. The only exception is *F. glutinosa* which has a shortly club-shaped or ellipsoid ovary 5–8 mm long.

In section *Macroscyphae* the ovary tapers at its top into a filiform sterile rostrum or beak (8–)10–20 mm long and about 1 mm in diameter. The three ovary chambers run up through the rostrum into the base of the style where they coalesce to form a single style canal. No vestiges of ovules occur in the rostrum. The only

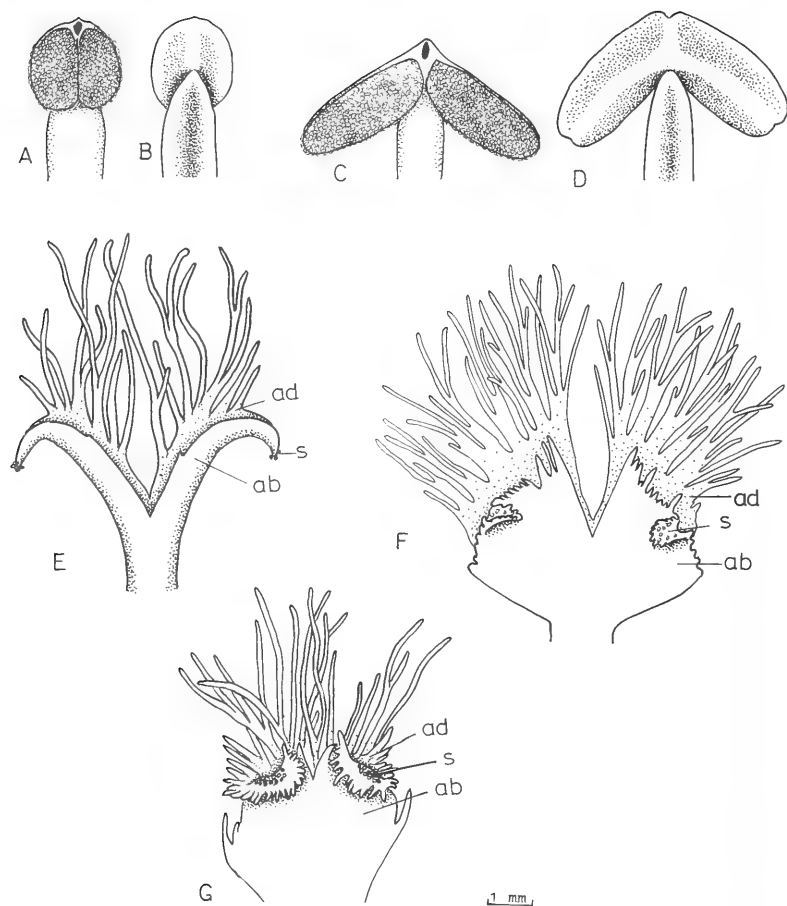


FIG. 5.

Stamens, style branches and stigmas of *Ferraria* species. A, B, *F. crispa* stamen: A, abaxial side, B, adaxial side; C, D, *F. divaricata* stamen: C, abaxial side, D, adaxial side; E, F, G, one style branch, lateral view of: E, *F. densepunctulata*; F, *F. divaricata*; G, *F. ferrariola*; ab, abaxial margin of style branch; ad, adaxial margin; s, stigma.

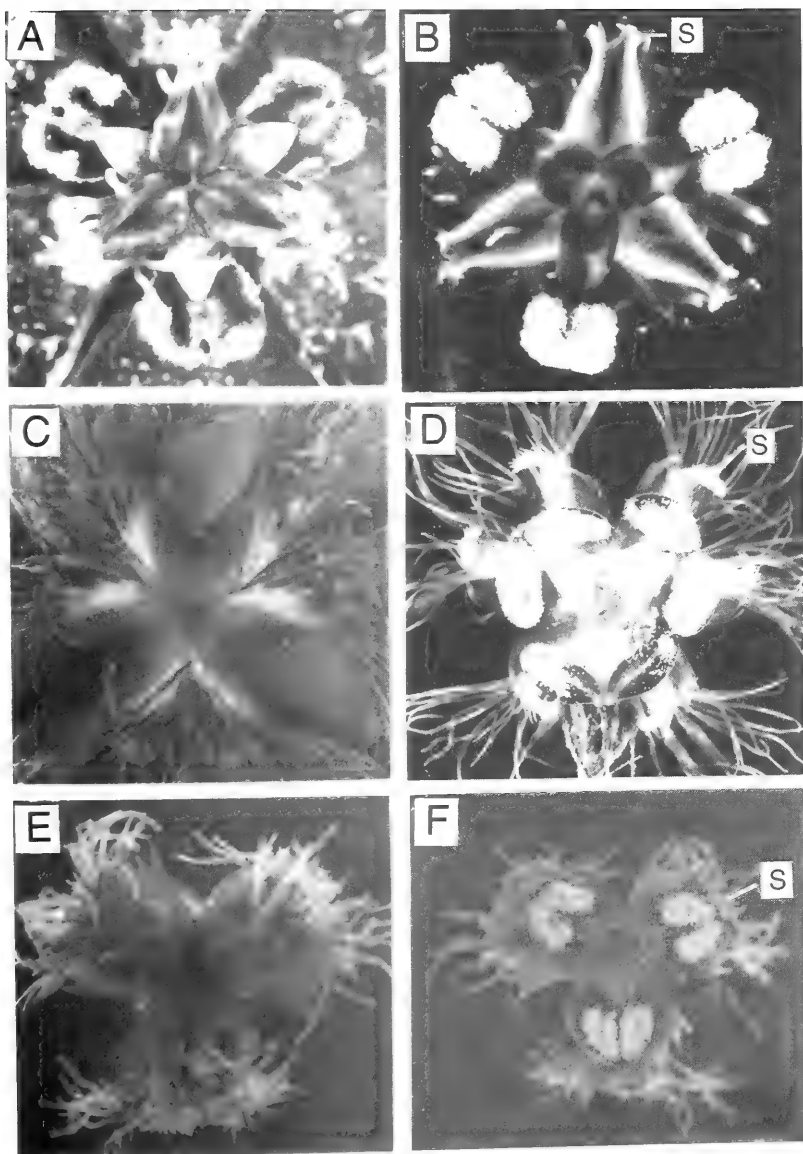


FIG. 6.

Style branches, stigmas and anthers of *Ferraria* species. A, B, *F. crispa*; C, D, *F. divaricata*; E, F, *F. ferrariola*; A, C, E, top view; B, D, F, seen from below. S, stigma; ca. $\times 5$.

other rostrate species is *F. schaeferi* of section *Ferraria* which has a short rostrum not more than 8 mm long. The other three species of this section also have a sterile top without ovules, 5–6(–7) mm long, but these ovaries are not described as rostrate, as the top is not filiform as in section *Macroscyphae*.

The style is (8–)10–15(–25) mm long. Above the filament tube it divides into three short spreading, bilobed or bipartite branches placed opposite the anthers. The six lobes or arms are fimbriate along their upper edges, and the fimbriae, mostly 4–6 μm in length, form an erect, usually dense tuft in the centre of the flower (Fig. 6).

Each style lobe or arm has two parallel transverse ridges at its upper edge (Fig. 5E–G), representing the free upper margins of the carpels comprising the gynoecium. The groove between the two ridges in each lobe is narrow, or almost completely closed and visible only in fresh specimens with the aid of a lens. Most fimbriae are outgrowths of the inner (adaxial) style ridge (Fig. E–G) nearer the centre of the flower. The outer ridge has fewer and shorter fimbriae or is almost smooth. The fimbriae are branched or unbranched; they vary in colour from pale yellow to dark purple and may be blotched. Anatomically a fimbria comprises an epidermal layer with domed outer cell walls and a narrow core of parenchyma in which a slender vascular strand is embedded. The style arms and stigmas which are below the fimbriae, are of diagnostic value:

In sections *Ferraria* and *Glutinosae* the three style branches are deeply bipartite with slender, sideways spreading, curved arms (Figs 5E, 6A, B), 3.5–5 mm long. The arms taper from ca. 1 mm at their bases to small terminal stigmas.

In section *Macroscyphae* the style branches are flattened and broadened from their bases (Fig. 5F), and 4 to 6 mm in width. They are usually not as deeply cleft as in section *Ferraria*. The shallow groove at the upper transverse edge terminates in a flattened or somewhat concave stigma which is curved outwards and towards the nearest anther lobe.

F. ferrariola is distinguished by its shallowly divided style branches and its flap-like stigmas which are formed by the enlarged outer (abaxial) style ridges only (Figs 5G, 6F). These are strongly recurved and bent outwards over the tops of the anthers, to expose their receptive surfaces. They bear a slight resemblance to the stigmatic flaps of *Moraea*, *Homeria* and *Dietes*.

Capsule The capsules have a thin, crustaceous, straw-coloured pericarp and are generally narrowly ellipsoid but with pointed tip, except in *F. glutinosa* where they vary from shortly ellipsoid to globose. They are mostly 20–40(–50) mm long and ca. 10 mm in diameter, and in *F. glutinosa* up to 15 mm in diameter. This is the only species where the ripe capsules are exserted above the spathes. In the Cape species the capsules become exserted laterally from the withering spathes.

The rostrum is persistent but does not elongate further after anthesis. After dehiscing loculicidally, the rostrum finally also splits into three valves.

The seeds are ca. 3–4 mm in diameter and usually golden-brown and shiny

when ripe. They are angled by pressure and roughly, though sparsely, wrinkled—except in *F. divaricata* subsp. *arenosa* and subsp. *aurea* where they are almost globose and foveolate-reticulate or finely reticulate.

CHROMOSOMES

The only previous report on the chromosomes of *Ferraria* is that of Goldblatt (1971) who examined *F. crispa* (as *F. undulata*), *F. ferrariola* (as *F. longa*) and a plant (ex hort.) named *F. cf. framesii* from the Caledon area, a doubtful identification.

The somatic chromosomes of all ten species of *Ferraria* have now been studied, including geographically distinct populations of seven of the species. This makes *Ferraria* cytologically one of the best known genera of Iridaceae (Figs 7–10).

Method Roots 7–10 mm in length, starting to sprout from corms, were pretreated for 4 hours in a solution of 0.001 M 8-hydroxyquinoline to which a few crystals of maltose had been added, and fixed in acetic-ethanol (1:3). After hydrolysis in N HCl at 60 °C for 9 minutes, they were stained with the Feulgen stain for 4–8 hours and squashed in 45 % acetic acid containing 0.25 % carmine. Some preparations were permanently mounted in euparal.

In order to make immediate use of plants collected from the veld, very young flower buds were sometimes cut up and used instead of root tips. (The latter only become available at the beginning of the following growing season or, when corms remain dormant longer than one summer, two or even three years later.) Although the chromosomes in flower buds are 12–25 % smaller than in root tips, they also give excellent squashes for chromosome examination.

Idiograms were drawn up from three, or rarely only two, metaphase plates of root tips, except where otherwise stated; they therefore do not represent the specific metaphase plates figured.

Observations Six of the Cape species, as well as the central African species *F. glutinosa*, are diploid with $2n = 20$ (Table 1). The basic number for the genus is $x = 10$ and is similar to that of *Dietes* and several subgenera of *Moraea* (Goldblatt 1971, 1976b).

Polyploidy occurs in three species, all three being heteroploid with diploid and tetraploid populations in *F. divaricata*, and tetraploid and hexaploid populations in *F. crispa* and *F. schaeferi*. These polyploids constitute distinct geographical races, and subspecific status has now been given to the races of *F. divaricata* and *F. crispa*, as some slight morphological differences also occur between the races. The tetraploid *F. divaricata* subsp. *australis* has established itself towards the south and south-east away from its diploid ancestors, and the hexaploid race of *F. crispa* has also migrated southwards. See under GEOGRAPHICAL DISTRIBUTION.

The hexaploid form of *F. schaeferi* has migrated northwards and occurs in the coastal area of the southern Namib desert near the type locality of the species. No

TABLE 1.

Chromosome numbers in *Ferraria* species. The localities are given as latitude-longitude squares.

Species	Diploid chromosome number	Herb. No. <i>De Vos</i> (or other)	Locality
Sect. <i>Glutinosae</i>			
<i>F. glutinosa</i>	20	2408	1127 Lubumbashi, Zaïre
Sect. <i>Ferraria</i>			
<i>F. foliosa</i>	20	2396	3017 Hondeklipbaai -DC
	20	2318	3218 Clanwilliam -AD
	20	2365	3218 Clanwilliam -AD
<i>F. crispa</i>			
<i>ssp. nortierii</i>	40	2374	3218 Clanwilliam -AB
	40	2354	3218 Clanwilliam -AD
	40	2375	3218 Clanwilliam -BA
	40	2376	3218 Clanwilliam -BD
	40	2401	3218 Clanwilliam -DC
<i>ssp. crispa</i>	60	2285	3317 Saldanha -BD
	60	2324	3318 Cape Town -BC
	60	2351	3322 Oudtshoorn -BC
	60	75/34	3418 Simonstown -BD
	60	2382	3420 Bredasdorp -CC
	60	2293	3421 Riversdale -BD
	60	Goldblatt (1971)	(Cape Town)
<i>F. schaeferi</i>	60	2379	2615 Lüderitz -CD
	40	2393	2615 Lüderitz -CB
	40	2392	2916 Port Nolloth -BD
	40	2391	2917 Springbok -CA
<i>F. densepunctulata</i>	20	2317	3218 Clanwilliam -AD
Sect. <i>Macroscyphae</i>			
<i>F. ferrariola</i>	20	2300	2917 Springbok -DB
	20	2372	3118 Vanrhynsdorp -AD
	20	Moffett 901	3118 Vanrhynsdorp -CA/B
	20	2294	3218 Clanwilliam -BB
	20	Goldblatt (1971)	(Botterkloof)
<i>F. divaricata</i>			
<i>ssp. divaricata</i>	20	75/16	2822 Glenlyon -AB
	20	2331	2917 Springbok -DA
	20	2386	2917 Springbok -BD
	20	2329b	2917 Springbok -DD
	20	2358	3118 Vanrhynsdorp -DA
	20	2353	3119 Calvinia -CD
	± 20	75/17	3120 Williston -AD
	20	2361	3218 Clanwilliam -BD
	20	2348	3219 Wupperthal -AA
<i>ssp. arenosa</i>	20	2356	3118 Vanrhynsdorp -CA
	20	2387	3118 Vanrhynsdorp -CB
	20	2295	3118 Vanrhynsdorp -DD
	20	76/14	3318 Cape Town -BD
	20	2385	3318 Cape Town -DC
<i>ssp. aurea</i>	20	2384	3118 Vanrhynsdorp -CA
	20	2333	3118 Vanrhynsdorp -DA

Species	Diploid chromosome number	Herb. No. <i>De Vos</i> (or other)	Locality
<i>ssp. australis</i>	20	2297	3218 Clanwilliam -AB
	40	2373	3118 Vanrhynsdorp -CB
	40	2290	3319 Worcester -AC
	40	2335	3319 Worcester -AD
	40	2299	3319 Worcester -DA
	40	<i>Moffett</i> 713	3320 Montagu -BA/B
	± 40		3322 Oudtshoorn -BC
	40	2380	3419 Caledon -AC
<i>ssp. divaricata</i>			
X <i>ssp. australis</i>	30	2389	3118 Vanrhynsdorp -DC
<i>ssp. australis</i>			
X <i>F. crispa</i>	50	2407	3319 Worcester -BD
<i>ssp. australis</i>			
X <i>F. crispa</i> ?	± 60	2405	3420 Bredasdorp -CA
<i>F. kamiesbergensis</i>	20	2399	3017 Hondeklipbaai -BC
	20	<i>Oliver</i> 5970	3018 Kamiesberg -CA
	20		3119 Calvinia -AB
<i>F. uncinata</i>			
<i>ssp. uncinata</i>	20	2359	3218 Clanwilliam -BD
	20	2325	3218 Clanwilliam -DC
<i>ssp. macrochlamys</i>	20	2329a	2917 Springbok -DD
	20	2328	3017 Hondeklipbaai -BB
<i>F. brevifolia</i>	20	2326	3118 Vanrhynsdorp -AB

subspecific name has been given to the tetraploid form of this species, as it does not differ morphologically from the hexaploid.

The size of the chromosomes of the Cape species of *Ferraria* range from 2–6(–7) μm in length with the method used, whereas the relatively primitive *F. glutinosa* from Zaïre has chromosomes 5–11 μm long (cf. Figs 7–10). A phylogenetic reduction in chromosome size has therefore taken place in the genus.

The karyotypes of the Cape species are remarkably similar, the haploid set comprising (Figs 8–10): two large chromosomes, *a*, *b*, almost equal in length with a subterminal centromere in the one and a somewhat less subterminal centromere in the other; three medium-sized chromosomes, *c*–*e*, with subterminal centromeres; two medium to small chromosomes, *f*, *g*, one with an almost completely median centromere and the other with a submedian one; and three small chromosomes, *h*–*j*, with more or less subterminal centromeres.

The two pairs of chromosome sets in the karyotype of the tetraploids, as well as the three sets in the hexaploids, show slight differences in chromosome sizes (Figs 8C–E). This may be an indication of allopolyploid origins.

Satellites are small and easily overlooked. They are mostly located on the short arm of one of the medium sized chromosomes.



FIG. 7.
Karyotype of *Ferraria glutinosa*.

In addition to their larger size, the chromosomes of the primitive *F. glutinosa* differ in being somewhat less asymmetrical, nine chromosomes of the set possessing submedian centromeres and one, *d*, a median centromere; there is also less difference in the sizes of the chromosomes (Fig. 7), the shortest chromosome being slightly more than half the length of the largest, and the average size of the eight shorter chromosomes being ca. 70 % of that of the longest two (whereas in the Cape species this percentage varies from 50 to 58 %) (Table 2). These observations are in accordance with Stebbins's statement (1950) that a more symmetrical karyotype often coincides with a relatively primitive external morphology.

TABLE 2.

Chromosome symmetry of the diploid *Ferraria* species. A, average length in μm of the two longest chromosomes; B, average length of the other eight chromosomes.

Species	A	B	% $\frac{B}{A}$
<i>F. glutinosa</i>	9,4	6,5	71
<i>F. foliosa</i>	6,2	3,5	57
<i>F. densepunctulata</i>	6,0	3,5	57
<i>F. ferrariola</i>	5,7	3,0	52
<i>F. divaricata</i> (diploid subspecies)	6,2	3,4	55
<i>F. kamiesbergensis</i>	6,3	3,5	55
<i>F. uncinata</i>	6,2	3,6	58
<i>F. brevifolia</i>	6,8	3,4	50

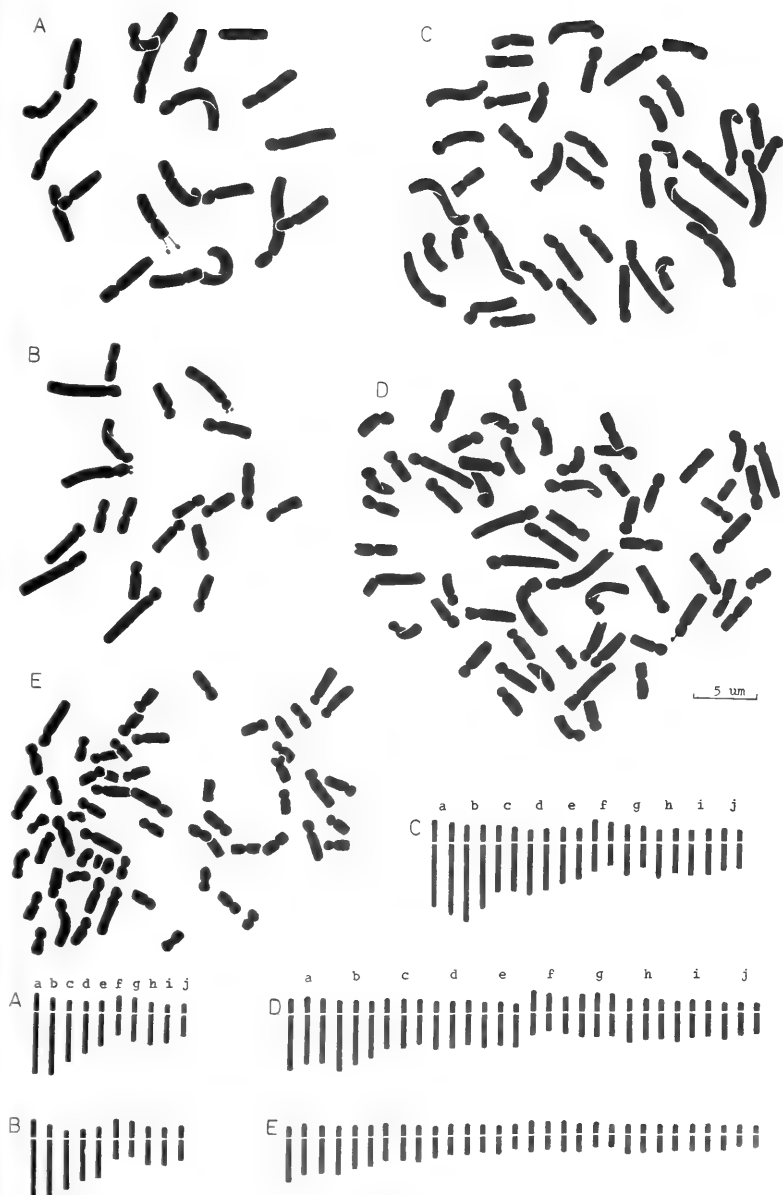


FIG. 8.

Karyotypes of *Ferraria* species, section *Ferraria*. A, *F. foliosa*; B, *F. densepunctulata*; C, *F. crispa* subsp. *nortierii*; D, *F. crispa* subsp. *crispa*; E, *F. schaeferi*.

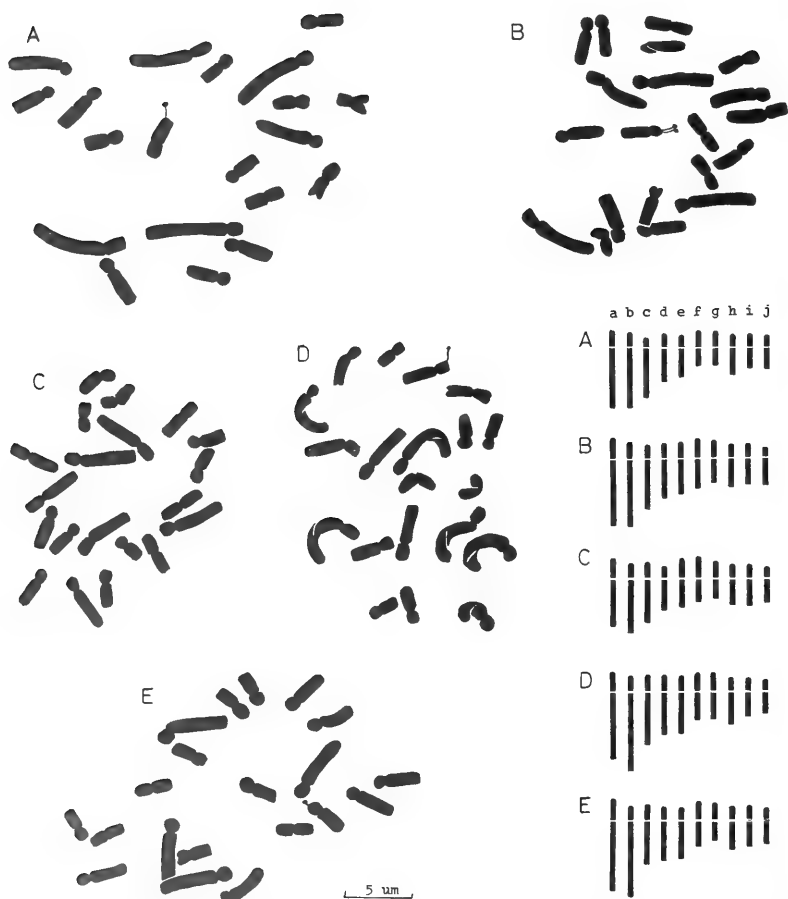


FIG. 9.

Karyotypes of *Ferraria* species, section *Macroscyphae*. A, *F. ferrariola*; B, *F. kamiesbergensis*; C, *F. uncinata* subsp. *uncinata* (with idiogram constructed from one metaphase); D, *F. uncinata* subsp. *macrochlamys*; E, *F. brevifolia*.

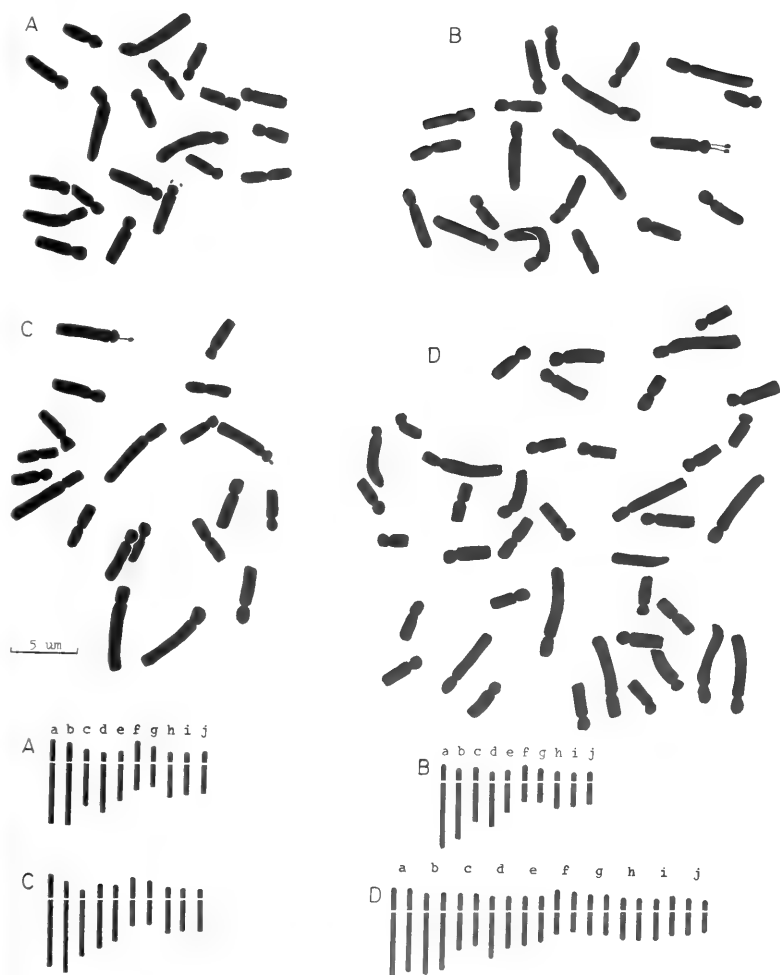


FIG. 10.
Karyotypes of *Ferraria divaricata* (section *Macrosyphae*). A, subsp. *aurea*; B, subsp. *divaricata*; C, subsp. *arenosa*; D, subsp. *australis*.

GEOGRAPHICAL DISTRIBUTION OF THE SPECIES AND NOTES ON THEIR ECOLOGY

Ferrarias are wide-spread in Africa south of the equator, from ca. 6° to the southern tip of Africa at $S\ 34^{\circ} 50'$, and from ca. $E\ 13^{\circ}$ to 31° , i.e. from the west coast to a southern extension of the Rift Valley.

All ten species occur in the Cape Province of the R.S.A. and nine of these grow in the winter rainfall region and are adapted to winter rainfall conditions. Most are concentrated on the western lowlands of the Cape Province below the first escarpment, from sea level to about 300 metres altitude. Two species, *F. foliosa* and *F. densepunctulata*, are local endemics with small ranges on coastal sand within 15 km of the coast (Fig. 11). *F. brevifolia* (Fig. 13B) also has a small range on sandy or gravelly shale somewhat more inland.

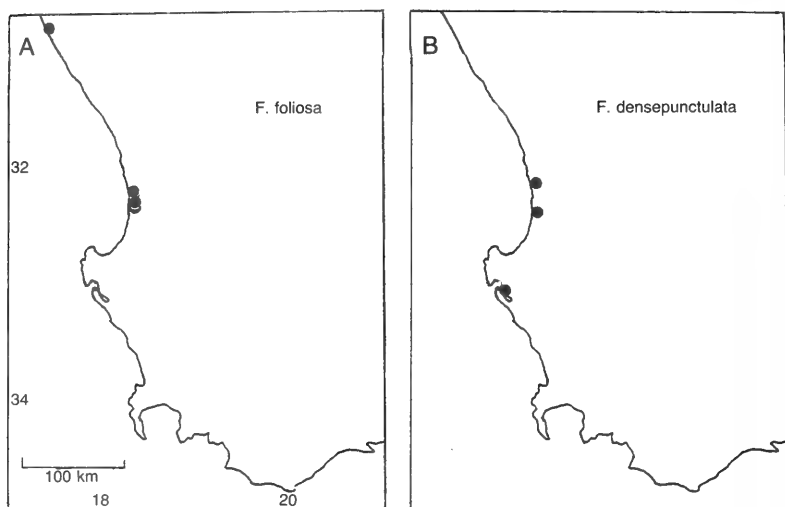


FIG. 11.

Geographical distribution of A, *Ferraria foliosa* and B, *F. densepunctulata*.

The other five species, namely *F. crispa*, *F. ferrariola*, *F. divaricata*, *F. kamiesbergensis* and *F. uncinata*, are more widely distributed (Figs 12–14) and have outliers towards, or on, the adjoining higher inland plateaux. Some of their localities are not typical winter rainfall areas, but the plants have retained their seasonal rhythm of sprouting in autumn, flowering in spring and being dormant during the summer. *F. divaricata*, with its four subspecies, has the widest distribution in the R.S.A., occurring throughout Namaqualand to the south-western Cape region and eastwards to Oudtshoorn (Fig. 14). One of its subspecies has also been found in the Great Karoo near Bristown, Carnarvon and Kenhardt, as well as in the Kalahari north of the Orange River.

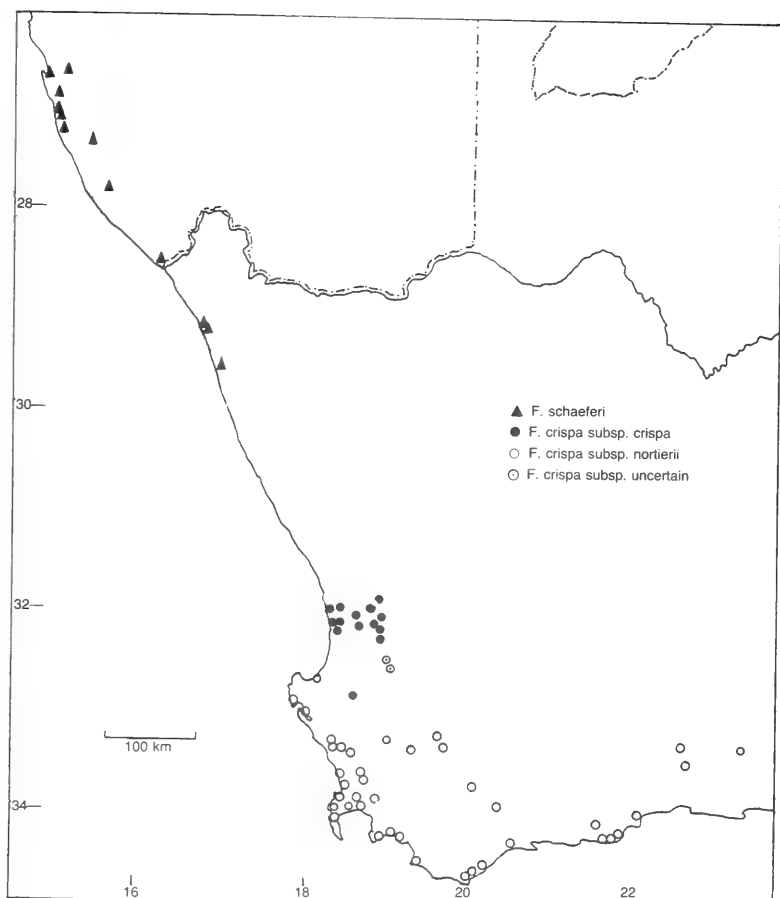


FIG. 12.
Geographical distribution of *Ferraria crispa* and *F. schaeferi*.

The highest concentration of species occurs in the latitude-longitude degree squares of 3218 (Clanwilliam) with six species and 2917, 3017, 3118, i.e. from Springbok southwards to Vanrhynsdorp with five species per square (Fig. 16). Levyns (1964) gave as her opinion that a genus with a maximum concentration of species in the Clanwilliam area or further north, is not part of the Cape Flora but belongs to the Karoo Flora which migrated later than the Cape Flora from the

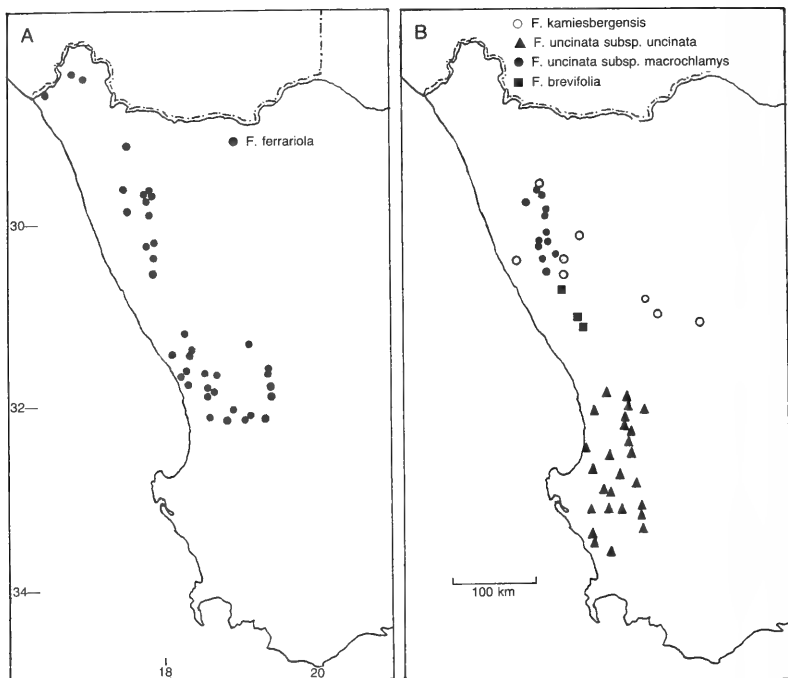


FIG. 13.

Geographical distribution of A, *Ferraria ferrariola*, and B, *F. kamiesbergensis*, *F. uncinata* and *F. brevifolia*.

north. She mentioned *Babiana* as an example. *Ferraria* also belongs in this category.

Most of the species in the above-mentioned degree squares are diploids and this region, from Springbok to Clanwilliam, probably constitutes a centre of development for the genus. In the south-western Cape region and the southern districts only polyploids (*F. divaricata* subsp. *australis* and *F. crispa* subsp. *crispa*) have been found, with a single exception of the diploid *F. divaricata* subsp. *arenosa* which has spread as far south as Bellville near the Cape. The only other polyploid species is *F. schaeferi* which spread northwards into the Namib desert from the above-mentioned developmental centre (Fig. 12).

Only three species occur to the north of the Republic (Figs 12, 14, 15). One, *F. glutinosa*, has the widest distribution of all *Ferraria* species and has been found in Zaïre, Zambia, Rhodesia, Angola, Namibia and Botswana, as well as in the Kalahari (northern Cape Province). This is the only summer-flowering species.

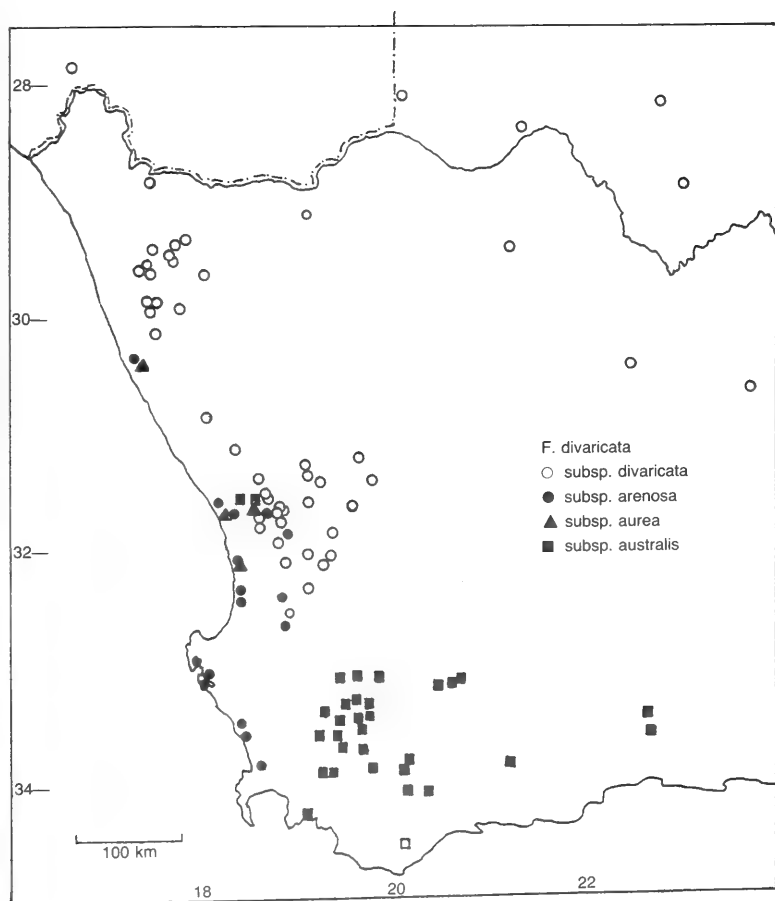


FIG. 14.
Geographical distribution of *Ferraria divaricata*.

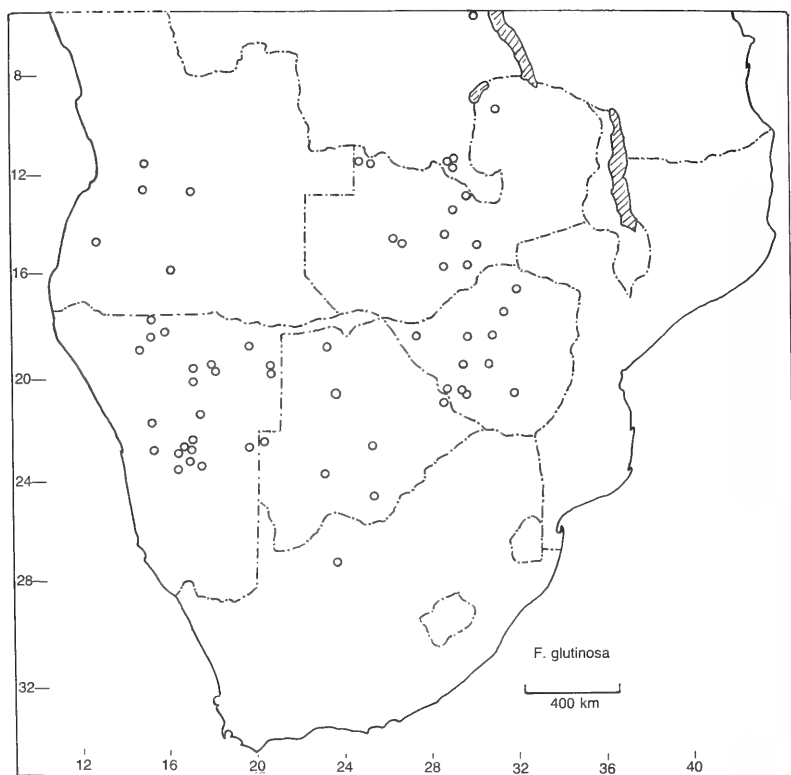


FIG. 15.
Geographical distribution of *Ferraria glutinosa*.

A second, *F. schaeferi*, has a small range in the southern Namib desert within 60 km from the coast, from Lüderitz Bay southwards into Namaqualand. The small amount of rain that falls in the southern Namib desert (less than 100 mm p.a.) occurs mostly in winter and *F. schaeferi* is adapted to winter rainfall conditions. The third, *F. divaricata* subsp. *divaricata* has been found once in southern Namibia.

The majority of *Ferraria* species are adapted to dry habitats. Rainfall maps show less than 100 mm p.a. over the coastal zone from Lüderitz Bay to the mouth of the Groenrivier and for approximately 40 km inland. Here four species occur, namely *F. schaeferi*, *F. foliosa*, *F. ferrariola* and a subspecies of *F. divaricata*. Perhaps the heavy sea mists which drift in from the coast, help these plants to grow and survive.

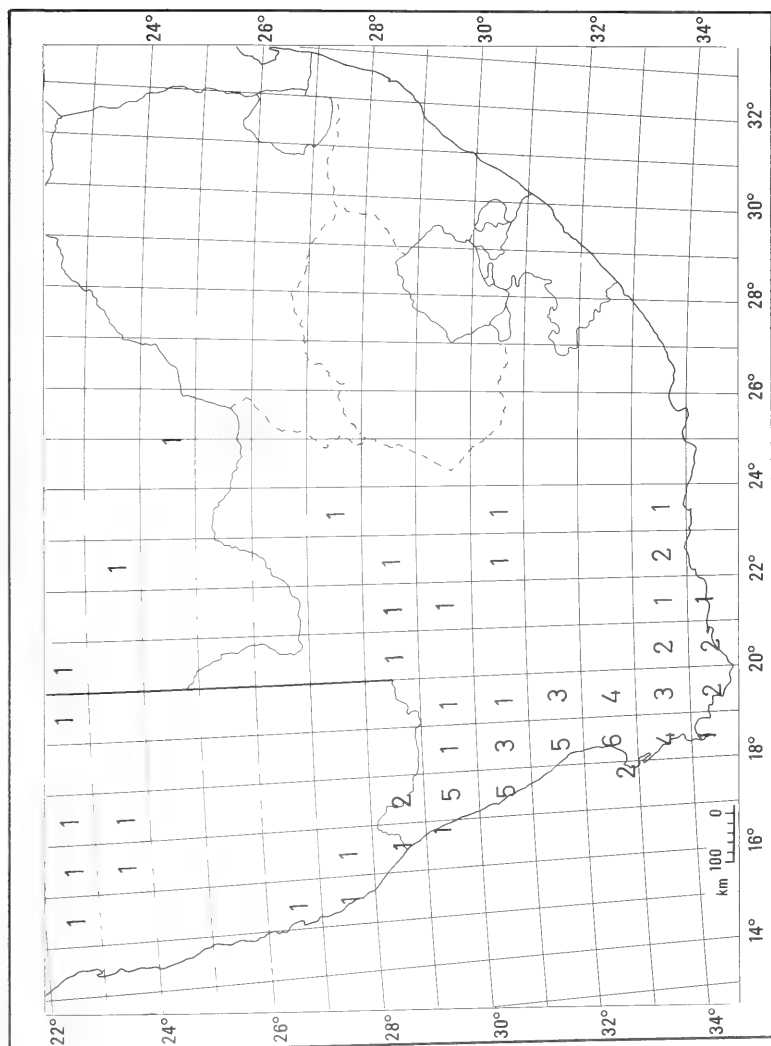


FIG. 16.
Ferraria species concentration in the R.S.A. and southern parts of Namibia and Botswana.

Inland, and adjoining this area, from the Richtersveld to Vanrhynsdorp, and southwards towards the coast near Lamberts Bay, is a wide zone with 100–200 mm of rainfall annually. Here all five species of section *Macroscyphae* have been recorded, as well as three of the four species of section *Ferraria*. South of Lambert's Bay the rainfall increases progressively towards the Cape Peninsula, and the number of species becomes fewer. In the Cape Peninsula only the hexaploid *F. crispa* occurs. (Fig. 12).

Most *Ferraria* species grow in sand; some, e.g. *F. schaeferi*, *F. foliosa*, and *F. densepunctulata* are confined to litoral sand. Other species, e.g. *F. crispa*, *F. ferrariola* and *F. divaricata*, generally grown in sandy soil, shale, or stony ground.

TAXONOMIC HISTORY OF *FERRARIA*

Ferrarias were brought to Europe even before the middle of the seventeenth century and cultivated there as items of interest, on account of their unusual flowers. The first description and illustration of a *Ferraria* was by an Italian, J. B. Ferrari, in his work *Flora seu de florum cultura*, published in Rome in 1633, and in Amsterdam in 1646, under a descriptive title *Flos indicus e violaceo fuscus radice tuberosa*.

Three more pre-Linnaean authors described and figured a *Ferraria* under descriptive titles: Morison (1680) named his plant *Gladiolus indicus e violaceo fuscus*; Rudbeck (1701) *Narcissus indicus flore saturate purpureo*; and Barrelier (1714) *Iris stellata cyclamine radice pullo flore*.

During the next two centuries Ferrarias were illustrated in works by Miller (1759a), Burman (1761), Jacquin (1770, 1804), Curtis (1791), Andrews (1803), Redouté (1803) and Sweet (1826, 1827).

The name *Ferraria* was first used in 1759 by two workers, namely Miller and Wännman. Miller, in his description, ascribed the name to Johannes Burman whose detailed description of the genus and of two species bears the date October 1758 but only appeared in 1761 in an obscure publication. It can therefore be deduced that Miller saw this description before its publication. (The two species described and figured by Burman are *F. crispa* and *F. fimbriata*. The latter, however, cannot be identified on account of its incorrectly drawn androecium and stigmas and an inadequate description of the flower; it is now excluded.)

In a work dated May 30, 1759, often ascribed to Wännman, but written by Linnaeus himself, mention is made of the genus in the following words (p. 361): "Nec minus singulares sunt *Ferraria* petalis undulatis", and on p. 370 *F. undata* (an orthographical error for *F. undulata*) is given, a nomen nudum.

Miller's figure (t.280) bears the date January 26, 1759. According to Stafleu (1967, p. 315) the dates on Miller's plates, though not necessarily the dates of publication, are probably very near this. If so, Miller's description of the genus,

which he ascribed to Burman, antedates that of Wännman. But in any case, the latter's two (or three) worded diagnosis cannot be regarded as a valid publication.

Linnaeus therefore erred in the second edition of the *Species Plantarum* (1763) when he used his own epithet *undulata*. He cited Burman's work of 1761 but overlooked Burman's epithet *crispa*, and made out that Burman had given the species only a descriptive title, *foliis nervosis*. As Linnaeus cited Burman's species in his circumscription of *F. undulata*, this name is superfluous and illegitimate; Moore (1974) already drew attention to this fact.

On account of the obscurity of Burman's publication, the genus has generally been ascribed to Linnaeus, notwithstanding the fact that Linnaeus again cited Burman as author of the name *Ferraria* in the sixth edition of the *Genera Plantarum* (1764). The only workers who acknowledged Burman were Sprengel (1830), Harvey (1838) in the first edition of his *Genera of South African Plants* (but not in the second edition of 1868), and Moore (1974).

The younger Linnaeus (1781) described an American species as *F. pavonia*, thereby broadening the circumscription of the genus. In the course of years numerous extra-African, and African, species were placed under *Ferraria*, Salisbury (1796), for example, recognised twelve *Ferraria* species, only one of which, *F. undulata*, is a true *Ferraria* by modern standards. Eleven of Salisbury's species were finally transferred to six different genera.

During the eighteenth century only one other true species of *Ferraria* was described, as *Moraea ferrariola* Jacq. In the nineteenth century Sweet (1826–27) described *F. obtusifolia*, *F. divaricata* and *F. uncinata*, and Ker (1804) described *F. antherosa*. Unfortunately Ker confused two species, citing as a synonym *F. viridis* which is an orthographic error for *F. viridiflora*, a different species described by Andrews (1803). As he cited as a synonym, his epithet is superfluous and therefore illegitimate and must be replaced by Sweet's epithet *divaricata* for this species. Most workers of the nineteenth century followed Ker in equating *F. antherosa* and *F. viridiflora*.

Klatt (1865–66) also caused confusion by recognising only three species, namely *F. obtusifolia*, *F. divaricata* and *F. undulata* and by citing five synonyms for the last mentioned species, none of which is *F. undulata*. He corrected this error in 1882 to some extent when he recognised three of these synonyms as distinct species.

Baker (1877, 1892, 1896) recognised six South African *Ferraria* species and in 1898 in the *Flora of Tropical Africa* another two species, namely *F. welwitschia* and *F. bechuanica*, from Angola and Bechuanaland respectively; he further described several tropical species of *Ferraria* under *Moraea*; these were later transferred to *Ferraria*. All these species described in 1898 were based on trivial differences such as flower colour, leaf width and plant size. Their types show that they are variations of a single species, *F. glutinosa*. Baker did not have enough material to recognise the differences as continuous variations.

During the twentieth century a further eight African species of *Ferraria* were described. Of these only three species, namely *F. schaeferi* Dinter, *F. foliosa* Lewis and *F. brevifolia* Lewis can be retained, the rest being synonyms of already described species.

ORIGIN AND RELATIONSHIPS OF *FERRARIA*

Ferraria belongs to the subfamily Iridoideae, tribe Irideae. Several workers considered the genus to stand closer to *Homeria*, *Hexaglottis* and *Tigridia* than to *Moraea*: Bentham and Hooker (1883) for example, placed *Ferraria* near *Homeria* and *Tigridia* in a group of species distinguished by connate filaments and bifid style branches which were a little shorter, or hardly longer, than the anthers. Pax (1888) placed *Ferraria* in his tribe *Tigridieae* subtribe *Cipurinae*, together with *Homeria* and *Hexaglottis*, while *Tigridia* went into subtribe *Tigridinae*. He placed *Moraea* together with *Iris* in another tribe *Moraeae* subtribe *Iridinae*. Diels (1930) did not distinguish subtribes, placing the above-mentioned genera, as well as *Dietes*, in one tribe, *Moraeae*.

Lewis (1954) followed Pax more or less, in recognising his subtribes *Cipurinae* (in which she also included *Galaxia*) and *Iridinae*, the latter comprising *Moraea*, *Dietes*, *Iris* and *Gynandriris*.

Goldblatt (1971), taking the karyotypes of the genera into consideration, split the subtribe *Cipurinae* into two, placing *Ferraria* as only genus in subtribe *Ferrariinae* and the genera *Homeria*, *Hexaglottis* and *Galaxia* in subtribe *Homeriinae*. He distinguished subtribe *Ferrariinae* from the *Homeriinae* in chromosome number, style with dissected feathery apex, in perianth segments, and corms almost naked. He regarded *Ferraria* as "a derivative of South African *Irideae* which diverged early from the line leading to *Moraea*, but after the single internode of the group corm had been evolved". Later (1976c) he came to the conclusion that *Moraea* and *Gynandriris* are allied to *Homeria* and transferred these genera from subtribe *Iridinae* to *Homeriinae*; but he kept *Dietes* in *Iridinae*.

To my mind also, there is sufficient reason for placing the genus *Ferraria* in a distinct subtribe. It is related to *Dietes* and *Moraea*, and probably originated (like *Moraea*, v. Goldblatt, 1976b), from a *Dietes*-like ancestor in central Africa south of the equator, where its most primitive species, *F. glutinosa*, still occupies a wide area. *Ferraria*, with a corm often comprising more than one internode, possibly diverged from the common stock which possessed a rhizome, before the single internode corm and the bifacial leaf of *Moraea* had evolved. Migration of *Ferraria* then took place to the western Cape region of the R.S.A. where the present developmental centre occurs. The basic chromosome number is $x = 10$ for *Dietes* and the primitive species of *Moraea* (Goldblatt, 1976b), as well as for *Ferraria*.

Probably the relationship of *Ferraria* with the new world genus *Tigridia* is not close. Molseed (1970) who monographed *Tigridia*, did not comment on this

aspect, except to mention that the data which the younger Linnaeus had, when he placed a *Tigridia* species with *Ferraria*, were inadequate. Goldblatt (1971) mentions that there is only a superficial resemblance between the flowers of the two genera. In truth, *Tigridia* differs in the possession of a bulb, spathes enclosing a condensed raceme, perianth segments without crisped margins, filaments entirely connate, and crestless style branches, as well as in chromosome number.

The only division of *Ferraria* into subgeneric species groups is by Baker (1877) who divided the genus into two groups, namely *Macroscyphae* comprising species with divaricate anther lobes, and *Brachyscyphae* with parallel anther lobes. As the latter includes the type species of the genus, this name is untenable for a section of the genus. The name *Macroscyphae* is, however, retained for one of the sections.

TAXONOMY

Ferraria Burm. ex Mill., Ic.: 187 (1759) & Gard. Dict. ed. 7 addenda (1759) & ed. 8 (1768); Burm., Nova Acta Acad. Caes. Leop.-Car. 2: 198 (1761); L., Sp. Pl. ed. 2, 2: 1353 (1763) & Gen. Pl. ed. 6, 465 (1764) & Syst. Nat. ed. 13, 597 (1770); Ker, in Kon. & Sims, Ann. Bot. 1: 241 (1805) & Irid. Gen.: 27 (1827); Roem. & Schult., Syst. Veg. 1: 345 (1817) pro parte; Spreng., Gen. Pl.: 527 (1830); Endl., Gen. Pl. 3: 166 (1837); Harv., Gen. S. Afr. Pl.: 334 (1838) & ed. 2: 372 (1868); Klatt, in Linnaea 34: 624 (1865-66); Bak., in J. Linn. Soc. Bot. 16: 105 (1877) & Hdb. Irid.: 72 (1892) & Fl. Cap. 6: 29 (1896); Benth. & Hook. f., Gen. Pl. 3: 692 (1883); Pax, in Nat. Pflanzenfam. 2(5): 148 (1888); Diels, in Nat. Pflanzenfam. ed. 2, 15a: 496 (1930); Lewis, in Adams. & Salter, Fl. Cape Penins.: 224 (1950); Phillips, Gen. S. Afr. Flow. Pl. ed. 2: 214 (1951) pro parte; Solch & Roessl. in Merxm., Prodr. Fl. SWA. 155: 3 (1969); Goldblatt, in J. S. Afr. Bot. 37: 438 (1971) & in Dyer, Gen. S. Afr. Flow. Pl.: 967 (1976). *Moraea* pro parte, Thunb., Diss. Moraea: (1787).

Plants small to medium sized, deciduous geophytes. *Underground stem* a group of persisting corms to which a new corm is added annually; corms hard, variously shaped, with tunics largely evanescent. *Aerial stem* erect, covered with leaf sheaths or rarely with partly bare internodes, branched in the upper portion, branches short. *Cataphylls* 1-3, sheathing the base of the shoot. *Foliage leaves* few to numerous, cauline, firm, glabrous, often glaucous, distichous or sometimes spirodistichous, equitant, suberect or spreading, with bifacial, sheathing leaf base and unifacial, ensiform to linear or rarely scimitar-shaped blade, upper leaves shorter and somewhat bract-like. *Cymes* few to numerous, terminal on main and lateral branches, 2-flowered or rarely with up to 6 flowers (*F. glutinosa*), enclosed in two large, erect, herbaceous spathes. *Pedicels* hidden by the spathes. *Flowers* actinomorphic, remaining open for 1-3 days. *Perigone segments* free, unguiculate, with suberect claws forming a cup, and with limbs spreading, soon reflexed, variously coloured, spotted and blotched with mostly dull colours, the limb

margins crisped, often discolourous, tips acute or acuminate, the outer segments slightly larger than the inner. *Filaments* united into a column around the style, with the upper 1–4 mm free and spreading; *anthers* appressed to the style branches, versatile, thecae parallel or divaricate from their bases, pollen yellow to orange. *Ovary* long, slender, often somewhat triquetrous, with numerous ovules, often tapering into a long, filiform rostrum at the top, rarely shortly club-shaped or ellipsoid (*F. glutinosa*); *style* erect, filiform, 3-branched above the filament tube, the branches short, cleft into two tapering diverging arms or into two broad flattened lobes below densely fimbriate crests; *stigmas* 6, below the fimbriae, minute and terminal on the tapering style arms, or somewhat flattened and marginal on the flat style lobes. *Capsules* ellipsoid with pointed tip, often crowned with a persistent rostrum, or rarely globose; *seeds* numerous, isodiametric, angled by pressure, wrinkled or sometimes reticulate-foveolate, brown to straw-coloured. Chromosome numbers $2n = 20, 40, 60$.

Type species: F. crispa Burm.

KEY TO THE SECTIONS

- 1 Stem partly naked, with gummy areas 10–30 mm long below each cyme; ovary less than 10 mm long. I. Section **Glutinosae**
- 1 Stem usually covered with leaf sheaths, rarely partly naked, but without gummy areas; ovary more than 10 mm long.
 - 2 Anthers with parallel thecae; ovary without a rostrum or rarely with a rostrum up to 8 mm long. II. Section **Ferraria**
 - 2 Anthers with divaricate thecae; ovary with a rostrum more than 10 mm long. III. Section **Macrocyphae**

KEY TO THE SPECIES

- 1 Stem with gummy areas below each cyme; ovary less than 10 mm long, erostrate. 1. **F. glutinosa**
- 1 Stem without gummy areas; ovary more than 10 mm long, rostrate or erostrate.
 - 2 Anthers with parallel thecae.
 - 3 Leaves ensiform or scimitar-shaped, blades more than 5 mm wide; stem stout, usually covered with leaf sheaths. 3. **F. crispa**
 - 4 Lower leaves with a distinctly thickened zone in the middle and a strong (pseudo) midrib, distichous, suberect or sometimes spreading. 2. **F. foliosa**
 - 4 Lower leaves with numerous veins about equal in size, often spirodistichous, spreading or recurved.
 - 5 Perianth segments 32–35 mm long, limbs maroon or dark purple with yellow-brown or brownish green margins; style branches with acuminate arms; south of Hondeklipbaai (30 ° S lat.). 2. **F. foliosa**
 - 5 Perianth segments 22–25(–30) mm long, limbs yellow with dark brown spots, blotches and margins; style branches with truncate arms; north of Hondeklipbaai. 4. **F. schaeferi**
 - 3 Leaves linear, blades of lower leaves up to 5 mm wide; stem slender with partly naked internodes.
 - 6 Base of shoot often with reddish purple leaf sheaths, but not spotted; outer perianth segments densely and minutely spotted; style branches with slender, acuminate arms and small terminal stigmas. 5. **F. densepunctulata**
 - 6 Base of shoot usually with reddish purple spotted and blotched leaf

- sheaths; outer perianth segments striate with short lines; style branches and stigmas flattened. 6. *F. ferrariola*
- 2 Anthers with divaricate thecae.
- 7 Foliage leaves short with short obliquely ovate blades which are shorter than the sheaths. 10. *F. brevifolia*
- 7 Foliage leaves or at least the lower ones, with linear to ensiform blades which are longer than the sheaths.
- 8 Margins of at least some of the foliage leaves crisped. 9. *F. uncinata*
- 8 Margins of leaves smooth.
- 9 Stem partly bare with the lower foliage leaves 1–5 mm wide; base of shoot with reddish purple spotted and blotched leaf sheaths; outer perianth segments striate with short lines. 6. *F. ferrariola*
- 9 Stem usually densely foliose with the leaves usually more than 5 mm wide; base of shoot not spotted or blotched; outer perianth segments without dark lines, but sometimes spotted or blotched.
- 10 Outer perianth segments 10–20 mm wide; flowers yellow-green, bluish green, orange to brown, or rarely golden yellow, with a wide bell-shaped perianth cup 13–20 mm diam. at the rim. 7. *F. divaricata*
- 10 Outer perianth segments less than 10 mm wide; flowers pale yellow with a narrow funnel shaped perianth cup 6–10 mm diam. at the rim. 8. *F. kamiesbergensis*

SECTION GLUTINOSAE De Vos, sect. nov.

Type species: F. glutinosa (Bak.) Rendle.

Caulis magnopere nudus, sub cymis glutinosus; *cymae* ad 6 flores habentes; *ovarium* minus quam 10 mm longum, erostratum; *stylus* et *stigmata* ut in sectione *Ferraria*; *capsula* globosa vel breviter ellipsoidea. *Chromosomatum numerus* $2n = 20$.

This section, comprising one species, stands near section *Ferraria*, corresponding in its anthers with parallel thecae and in the shape of the style branches, stigmas and perianth cup. Its leaf anatomy also indicates a closer relationship with section *Ferraria* than with section *Macroscyphae*, in the sclerenchyma of the larger veins lying against the epidermis, in the absence of epidermal papillae and in the possession of two large veins which form a pseudo-midrib. The fine, homobrochate pollen sculpture, however, resembles that of section *Macroscyphae*.

It differs from the other two sections of the genus in the smaller amount of water storing tissue in the leaves, in its summer flowering habit, its largely naked, laxly branched stem with viscid areas below the cymes in which up to six flowers develop, and in its short ovary and globose or shortly ellipsoid capsule.

1. *Ferraria glutinosa* (Bak.) Rendle, Cat. Welw. Afr. Pl. 2: 27 (1899); Carter in Kew Bull. 17: 317 (1963); Sölch & Roessl., in Merxm., Prodr. Fl. SWA. 155:4 (1969); Goldblatt, in Ann. Mo. Bot. Gdn. 64: 294 (1977).

Moraea glutinosa Bak., in Fl. Trop. Afr. 7: 271, basionym. *Type*: Angola, Huilla near Lopollo, Welwitsch 1543 (BM, holo; K, P, LISU, iso)—& Hdb. Irid.:

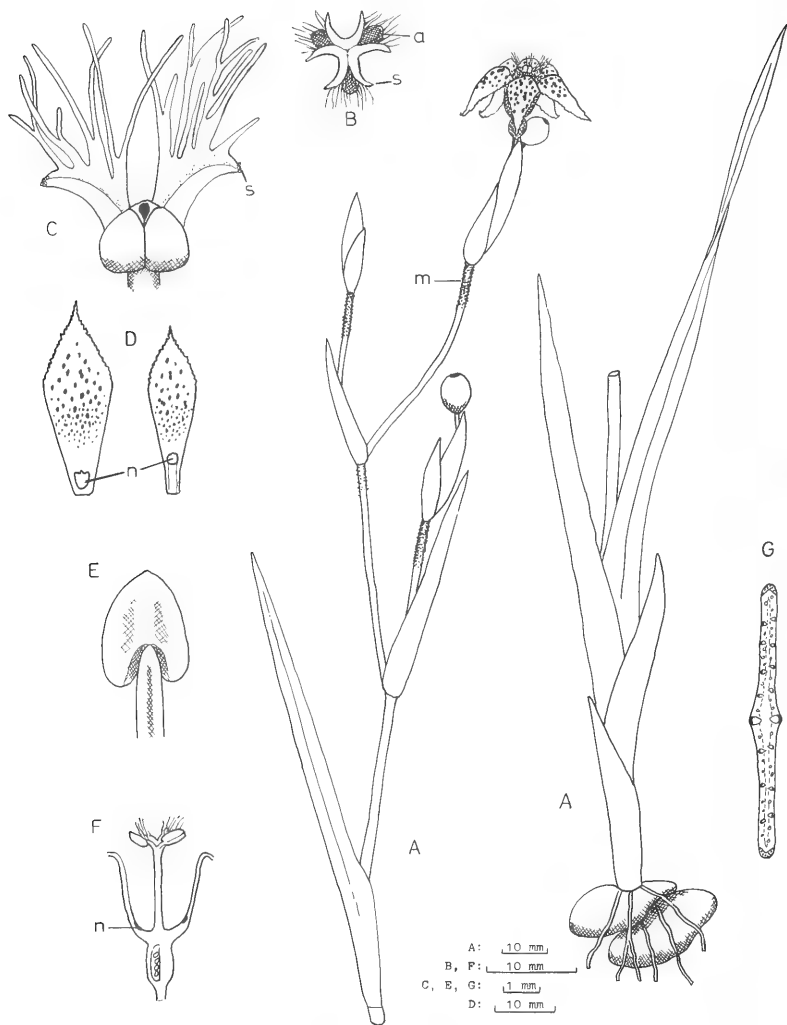


FIG. 17.

Ferraria glutinosa. A, plant; B, style branches and anthers as seen from above; C, one style branch and anther, lateral view; D, outer (left) and inner (right) perianth segments; E, stamen above filament tube, adaxial view; F, longitudinal view of perianth claws, pistil and stamens; G, transverse section of leaf blade; a, anther; m, gummy area with adhering sand grains; n, nectaries; s, stigma.

55 (1892) & Fl. Trop. Afr. 7: 342 (1898); Klatt, in Abh. Naturf. Ges. Halle 15: 367 (1882) & in Dur. & Schinz, Consp. Fl. Afr. 5: 150 (1895).

M. spithamea Bak., in Trans. Linn. Soc. ser. 2, Bot. 1: 271 (1878). *Type*: Angola, Huilla, around Lopollo & Humpata, *Welwitsch 1547* (BM, lecto; K, iso); & Hdb. Irid.: 55 (1892) & in Fl. Trop. Afr. 7: 341 (1898); Carter, in Kew Bull. 17: 317 (1963) pro syn.; Sölch & Roessl., in Merxm., Prodr. Fl. SWA. 155: 4 (1969) pro syn.

M. candelabrum Bak., in Trans. Linn. Soc. ser. 2, Bot. 1: 271 (1878). *Type*: Angola, Huilla, Morro de Lopollo, *Welwitsch 1544* (BM, lecto; K, LISU, iso); & Hdb. Irid.: 54 (1892) & in Fl. Trop. Afr. 7: 342 (1898); Engl., Hochgebirgsfl. trop. Afr.: 173 (1892).

Ferraria candelabrum (Bak.) Rendle, Cat. Welw. Afr. Pl. 2: 27 (1899).

Moraea andongensis Bak., in Trans. Linn. Soc. Ser. 2, Bot. 1: 271 (1878) pro parte. *Type*: Angola, Pungo Andongo, *Welwitsch 1532* (BM, lecto; K pro parte, LISU, iso); Goldblatt, in Ann. Mo. Bot. Gdn. 64: 294 (1977) pro syn.

Ferraria andongensis (Bak.) Rendle, Cat. Welw. Afr. Pl. 2: 27 (1899); Goldblatt, 1977 l.c. pro syn.

F. welwitschii Bak., Hdb. Irid.: 74 (1892). *Iconotype*: unpublished (K); & in Fl. Trop. Afr. 7: 344 (1898); Rendle, Cat. Welw. Afr. Pl. 2: 27 (1899); Carter, in Kew Bull. 17: 317 (1963) pro syn.; Sölch & Roessl., in Merxm., Prodr. Fl. SWA. 155: 4 (1969) pro syn.

F. bechuanica Bak., in Fl. Trop. Afr. 7: 344 (1898). *Type*: Ngamiland, Kalahari Desert, near Mamumwe, *Lugard 237* (K, holo); Brown, in Kew Bull. 1909: 142; Carter, in Kew Bull. 17: 317 (1963) pro syn.; Sölch, Diss. München: 127 (1961); Sölch & Roessl., in Merx. Prodr. Fl. SWA. 155: 4 (1969) pro syn.

Moraea randii Rendle, in J. Bot. Lond. 36: 144 (1898). *Type*: Rhodesia, Bulawayo, *Rand 233*, Jan. 1898 (BM, holo.; BR, iso.).

Ferraria randii (Rendl.) Rendle, in J. Bot. Lond. 43: 54 (1905).

Moraea aurantiaca Bak., in Fl. Trop. Afr. 7: 575 (1898). *Type*: Angola, Malange, *Von Mechow 303* (B, not seen; drawing of holotype in K); Goldblatt, in Ann. Mo. Bot. Gdn. 64: 294 (1977) pro syn.

M. kitambensis Bak., in Fl. Trop. Afr. 7: 575 (1898). *Type*: Angola, Bangala, *Buchner 679* (B, not seen, K); Goldblatt, 1977 l.c. pro syn.

F. viscaria Schinz, in Mem. Herb. Boiss. 10: 77 (1900). *Type*: Namibia, Omupanda, *Wulfhorst 45* (Z, holo); Sölch, Diss. München: 127 (1961); Sölch & Roessl., in Merxm. Prodr. Fl. SWA. 155: 4 (1969) pro syn.

M. malangensis Bak., in Bull. Herb. Boiss. ser. 2, 1: 862 (1901). *Type*: Angola, Malange, *Von Mechow 386* (B, holo, not seen); Goldblatt 1977 l.c. pro syn.

F. hirschbergii L. Bol., in S. Afr. Gard. 22: 57 & 59 (1932). *Type*: Belgian Congo, near Elizabethville, *Von Hirschberg NBG 615/29* (BOL, holo; K, iso); Carter, in Kew Bull. 17: 317 (1963) pro syn.

Icons: An unpublished figure, as *F. welwitschii*, in K, made for the Regium; two unpublished figures by G. J. Lewis in BOL; this work Figs 17, 15.

Plants (200–)400–700(–900) mm tall. *Corm* depressed globose or irregular, 10–40 mm diam., often comprising several internodes, brown or dark brown. *Stem* (200–)400–700(900) mm long, laxly and often repeatedly branched, with long, largely naked internodes and sticky areas 10–25 mm long below the cymes and many upper nodes. *Cataphylls* 1–3, 50–120 mm long, sheathing. *Foliage leaves* several, 50–200(–600) mm long, shorter towards the top and sometimes also the base of the stem, 4–8 mm wide, linear to narrowly lanceolate, tapering gradually to an acuminate tip, often consisting almost entirely of a bifacial sheath, or the lower ones with a short, or rarely long, unifacial blade, thin in texture, with a stronger median vein. *Cymes* several, solitary at the ends of elongated naked branches, with 2–6 flowers per cyme. *Spathes* not keeled; outer spathe 15–25 (–30) mm long, with narrow, pale or reddish membranous margins, obtuse to acute; inner 30–45(–50) mm long, with membranous margins and a tip which often becomes lacerated later. *Flowers* 30–40 mm long, exserted, almost odourless, brown, maroon or deep purple often spotted and mottled with yellow and with yellow or greenish-yellow narrow margins, or cream or yellow with brown or purple spots and blotches. *Perianth cup* widely bell-shaped, ca. 10 mm deep, 15 mm diam. at the rim, with slits between the claws; nectaries bilobed or entire, 2–5 mm above the claw bases, on the inner claws often slightly higher than on the outer; *segments* horizontal or recurved, with finely crisped margins and acute or acuminate tips; outer segments 28–35 × 8–13 mm with wide claws, inner 25–28 × 5–9 mm, with narrow claws. *Filament tube* 8–10 mm long, the free upper portions 2–3 mm long; *anthers* 5 mm long at first, later 2.5 mm, with parallel thecae and orange or yellow pollen. *Ovary* 5–7 mm long, club-shaped or ellipsoid, not rostrate; *style* ca. 10 mm long, with branches 4 mm long, as in *F. crispa*; *stigmas* terminal. *Capsules* usually 1–2 from a cyme, globose or shortly ellipsoid or obovoid, 12–20(–25) × 10–15 mm, exserted from the spathes; *seeds* shiny brown, up to 5 mm diam., with an irregularly wrinkled testa.

Chromosome number: $2n = 20$.

Flowering period: (October–) November–February (–May).

Distribution: This species has the widest distribution of all *Ferrarias*, occurring in central African countries south of the equator and west of an extension of the Rift Valley, and extending to the Kalahari of the Cape Province and the middle of Namibia. It has, strangely, not been found in Malawi and Transvaal.

ZAÏRE—0528: Niemba (–CC), *De Saeger s.n.* 8.10.34 (BR).

—1127: Lubumbashi area, *Boussard* sub *De Vos* 2408 (STE), *Quarré* 3633 (K); Haut Katanga, environs de Lubumbashi, *Lisowski* 108 (K, BR); Elizabethville, *Von Hirschberg* NBG 618/29 (BOL, SAM); 9 Km ou NE de Lubumbashi, *Bulaimu* 361 (BR); 28 Km ou NE de Lubumbashi, *Malaisse* 7402 (BR); Dambo

Mukuen, *Detilleux* 158 (BR); Keyberg, 8 km SO d'Elizabethville, *Schmitz* 215 (BR).

ANGOLA—1115: Cuanza Sul, Cela-Cassamba, *Teixeira & All* 7396 (LISC).

—1215: Huambo, Nova Lisboa, *Da Silva* 3340 (K, PRE, BR); Chipie, *Stopp* 122 (K);

—1217: Cuemba, Margens do rio Semena, Camacupa, *Teixeira & M.M.* 8683 (LISC).

—1413: Huila, Lubango, Hoque na picada para Dinde, ao km 5—, *De Menezes* 340 (K, PRE, SRGH); Near Lopollo, *Welwitsch* 1567 & 1543 (K); Morro de Lopollo, Huilla, *Welwitsch* 1544 (K).

—1516: Cuene, Cuvelai, *Menezes* 4270 (SRGH).

ZAMBIA—0929: Kawambwa Distr. Luapula Leper Settlement, *Richards* 15485 (K, SRGH).

—1123: Kitwe, *Mutumushi* 2376 & 2843 (K), *Fanshawe* 5314 (K), & 7166 (K, SRGH).

—1124: Mwinilunga, Kalenda Ridge, *Milne-Redhead* 2664 (K, BR); Kabompo Gorge, *Richards* 17475 (K); Woodland below Matonchi, *Richards* 17278 (K, SRGH); Near Mujileshi River, *Richards* 16902 (K, SRGH).

—1228: Mufulira, *Cruse* 92 & 221 (K).

—1327: Chingola, *Linley* 218 (PRE, SRGH).

—1425: Mankoya, about 30 mls W of Kafue Hook pontoon, *Drummond & Cookson* 6734 (PRE, K, SRGH); Kafue Nat. Park, *Lawton* 1178 (K).

—1427: Mumbwa, *Macaulay* 993 (K).

—1527: Mazabuka, Ridgeway Road, *C.R.S.* 541 (PRE, K).

—1528: Lusaka, Vallée de Lufuko, *Quarré* 7505 (BR).

RHODESIA—1630 (Mazoe): Umvukwes (-DD), *Wild* 3911 (PRE, K, SRGH).

—1826 (Wankie): Ngano Pass, Gwaai Reserve, *Paterson* 8 (SRGH).

—1828 (Gokwe): Charama rd., *Bingham* 393 (PRE, SRGH); Sergwa Res. Sta., *Jacobsen* 404 (SRGH).

—1829 (Queque): Mlezu School Farm 18 mls SSE of Queque, *Biegel* 720 (K, SRGH).

—1928 (Nyamandhlovu): Bongola Farm, *West* 3064 (SRGH).

—1929 (Gwelo): Gwelo (-DB), *Holland NBG* 92/28 (BOL, K).

—2027 (Plumtree): Plumtree (-BD/DB) *Eyles Hb.* 8543 (K, BR), *Brain* 10919 (SRGH).

—2028 (Bulawayo): Bulawayo (-CA), *Brain* 5056 (SRGH), *Norman* R44 (K), *Eyles* 158 (BM, SRGH), *Garley* 628 (K, SRGH); Matoppos (-AD), *Eyles* 3761 (SRGH); Black Land Paddocks, *Rattray* 440 (BM, K); Matobo, Schumbashaba farm, *Miller* 2569 (K, PRE, SRGH); Essexvale (-BD), *Cheeseman* 16 (BM).

—2030 (Fort Victoria)? Victoria, *Monro* 2234 (S).

NAMIBIA—1715 (Ondangua): Oshikango (-BD), *Rodin* 9360 (WIND, M).

—1815 (Okahakana): Onolongo (-BC), *Barnard* 378 & 132 (SAM).

- 1816 (Namutoni): 30 mls SE of Ondangua (-AA), *De Winter* 6938 (PRE).
 - 1819 (Karakuwisa): Cigarette NE of Karakuwisa (-DD), *Maguire* 2292 (NBG).
 - 1917 (Tsumeb): Tsumeb (-BA), *Dinter* 1840 (SAM).
 - 1918 (Grootfontein): Grootfontein (-CA), *Dinter* 2385 (SAM); Farm Bloekane distr. Grootfontein, *Rehm s.n.* (M); Bubus (-CA), *Dinter* 860 (SAM).
 - 1920 (Tsumkwe): 6 km ostlich Tsumkwe (-DA), *Giess, Watt & Snyman* 11027 (PRE, WIND, M, S); 157 mls E of Grootfontein (-DA), *Story* 6156 (PRE, WIND, M); Nama Pan (-DC), *Story* 5313 (PRE), *Maguire* 2142 (NBG); Gautscha Pan (-DC), *Maguire* 2190 (NBG).
 - 2115 (Karibib): Near Karibib (-DD), *Kinges* 3189 (PRE, M).
 - 2117 (Otjosondú): Omipanda (-BD), *Wulffhorst* 45 (Z); Quickborn, (-AA), *Bradfield* 146 (PRE).
 - 2215 (Trekopje): Donkerhuk (-DD), *Barnard* 79 (PRE, WIND).
 - 2216 (Otjimbingwe): Friedenau, Khomas Hochland (-DB), *Gasner* 160 (M).
 - 2217 (Windhoek): Farm Frauenstein (-AD), *Giess* 13901 (PRE); Ostl. Auasberge (-CA), *Dinter* 403 (Z); Nordanläufer der Auasberge, *Dinter* 1870 (SAM). Goreangab dam, *Giess* 8395 (WIND); Distr. Windhoek, *Volk* 11168 (M).
 - 2219 (Sandfontein): Sandfontein (-BD), *Bleek* BOL 17247.
 - 2316 (Nauchas): Abbabis (-CC), *Dinter* 1456 (Z).
 - 2317 (Rehoboth): Farm Bergland (-AC), *Merxmüller & Giess* 1278 (BR, K, M, WIND). Rehoboth-Aub, *Dinter* SAM 73068 (SAM); Ca. 20 mls N of Uhlenhorst (-DB), *Boshoff & Mason* 3619 (PRE).
- S.W.A.: Lichtenstein, without precise locality, *Dinter* 4311 (B, BM); Heufeld, *Volk* 452 (M).

BOTSWANA—1822 (Kangara): Dobe (-DD), *Lee* 103 (SRGH).

- 2023 (Kwebe Hills): Near Kwebe Hills, Ngamiland (-CA), *Lugard* 282 (K).
- 2027 (Plumtree): 4 mls S of Tsessebe (-DC), *Leach & Noel* 298 (K, SRGH).
- 2220 (Kalkfontein): Near Mamumwe, Kalahari desert (AA/C), *Lugard* 237 (K).
- 2322 (Kang): 50 mls N of Kang (-DB), *Wild* 5066 (SRGH).
- 2424-25 (Dikgomo di kae—Gaberone): Letlhakeng-Sesung road, *Wild* 4977 (SRGH).

CAPE—2723 (Kuruman): Esperanza (-AD), *Ferrar* 6575 (KMG), *Essterhuysen* 2219 (BOL); Kormutsetla (-BB), *Cross* 10088 (PRE).

This widely distributed species is readily distinguished from all South African species of *Ferraria* by its lax habit, long naked internodes with zones of gummy exudation below the cymes, and by its very short ovary without a rostrum.

Its flowering period varies widely, from November in tropical countries, to April or even May in southern localities. In the tropics it often flowers before development of the new season's corm.

It stands closest to section *Ferraria* which it resembles in its parallel anther lobes, narrow style arms and small terminal stigmas, and in its perianth with a

wide, rather shallow cup. In flower colouring it resembles *F. crispa*, varying in a similar manner. The flowers are described as scentless or almost scentless.

Carter (1963), examining the types of tropical African Iridaceae in the Kew herbarium, found four species described by Baker and by Bolus to be conspecific with *F. glutinosa*; and Goldblatt (1977) discovered under *Moraea* several more species names which are also synonymous with this species. In the course of the present investigation the types of all the synonyms, except three in Berlin, were reinvestigated and found to be conspecific with *F. glutinosa*, with the exception of *M. andongensis* Bak., the type of which in K, as well as Baker's description of its corm, ("fibris multis gracilibus praeditum") shows that this is not a *Ferraria*. But Rendle (1899), working with the type material in the BM which is undoubtedly a *Ferraria*, transferred *M. andongensis* to *Ferraria*, and corrected Baker's description of the corm.

With the large amount of material now available for investigation from various herbaria, it is clear that the characters such as plant size, size and shape of the corm, number of flowers to a cyme, and flower colouring, used by Baker and other workers to distinguish their species, form continuous variations, so that no demarcations can be drawn to delimit separate species or even subspecies. As Carter suggested, plant size is undoubtedly influenced by environmental conditions and by the age of the plant; variation in flower colouring, however, is not due to age but is genetically fixed, as in the case of several of the southern species.

II SECTION FERRARIA

Stem much branched and densely foliose except in *F. densepunctulata*. *Cymes* generally 2-flowered. *Perianth claws* forming a wide bell-shaped cup 8–10 mm deep, with narrow slits between the claws. *Nectaries* 3–6 mm wide, usually wider than long, 1–4(–7) mm above the bases of the claws. *Anthers* with parallel thecae. *Ovary* 12–25 mm long, not rostrate or rarely with a rostrum ca. 8 mm long; *style* with deeply bifid or bipartite branches, the arms narrow, spreading sideways with minute terminal stigmas. *Capsule* usually not rostrate.

Chromosome numbers: $2n = 20, 40, 60$.

Type species: *F. crispa* Burm.

This section, comprising four species, has three species closely related, and the fourth, *F. densepunctulata*, differing in habit, leaf shape and anatomy, and in flower colouring. The leaves usually have two larger veins which form a pseudo-midrib. Epidermal papillae are lacking except in some collections of *F. schaeferi*. The larger veins lie with their sclerenchyma against the epidermis, except in *F. densepunctulata*. Pollen grains show a heterobrochate sculpture.

This is the only section in which hexaploids occur. These show remarkable fertility, indicating possible allopolyploid origins.

Distribution: Mostly in coastal districts from Lüderitz in Namibia to the Cape Peninsula, and eastwards to Mossel Bay, as well as to Oudtshoorn and Willowmore.

2. **Ferraria foliosa** Lewis, in Ann. S. Afr. Mus. **40**: 117 (1954). *Type*: Cape, near Elandsbaai, *Lewis 2301* (SAM 60809) (SAM, hol.; STE, iso.).

Icones: Lewis l.c. p. 118; this work Figs 18, 11A.

Plants 300–600(–900) mm tall. *Corm* depressed globose or somewhat cone-shaped, 20–50 mm diam. *Stem* 300–600(–750) mm long, stout, foliose, hidden by leaf sheaths. *Cataphylls* 2–3, unspotted. *Foliage leaves* numerous, 120–250 mm long, spirodistichous in large plants, glaucous, scimitar-shaped, spreading almost horizontally or slightly recurved, with wide, seemingly inflated sheaths up to 50 mm wide (folded), with pale membranous margins and numerous parallel veins, narrowing to short unifacial laminas ca. 6–8 mm wide, obtuse and mucronulate or subacute. *Cymes* numerous, 2-flowered. *Spathes* often keeled towards obtuse or subobtuse tips, with narrow, pale, membranous margins; outer 30–35 mm long, inner 40–45 mm long. *Flowers* 40–45 mm long, with an unpleasant mouldy odour, dark maroon or dark purple, velvety, with yellow-brown or brownish-green margins. *Perianth cup* widely bell-shaped, 10 mm deep, 15–18 mm diam. at the rim, with narrow slits between the claws, spotted inside, the claws with a swollen median zone; *nectaries* deeply bilobed, concave, ca. 2 mm above the claw bases, ca. 4 × 3 mm, shiny black or with dark spots, and with a narrow, pale upper margin often giving a 12-rayed pattern inside the cup; *segments* acuminate, outer segments 33–35 × 12–15 mm, often somewhat eared above the claws, inner 30–32 × 10–12 mm. *Filament tube* 6–8 mm long, often spotted, the free upper portions 2–3 mm long, slightly patent; *anthers* with parallel thecae, at first ca. 5 mm long, later 2 × 2 mm, dark on the backs, with orange pollen. *Ovary* 15–20 mm long, without a rostrum; *style* 8 mm long, the branches 4–5 mm long, deeply cleft into two curved, sideways spreading acuminate arms, the fimbriae sparse, blotched, ca. 3–5 mm long; *stigmas* minute, terminal on the style arms. *Capsules* ellipsoid or shortly cylindrical, 28–35 mm long, erostrate; *seeds* 3 mm diam., golden brown, with a shiny, finely wrinkled testa.

Chromosome number: $2n = 20$.

Flowering period: August to October. Each flower remains open for one day (10–16 hours).

Distribution: A coastal species growing in deep coastal sand, from just above the high water mark to 15 km inland, from Groenrivier mouth to Elands Bay, over a distance of ca. 130 km.

CAPE—3017 (Hondeklipbaai): At coast, Groenrivier mouth (–DC), *De Vos 2396* (STE).

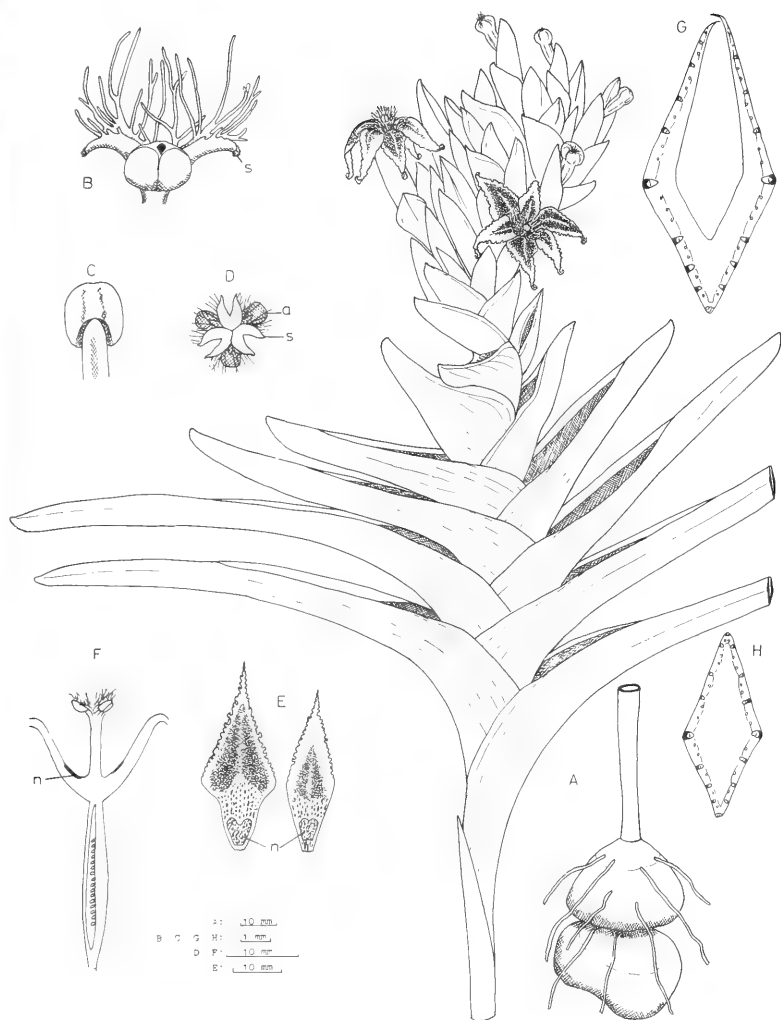


FIG. 18.

Ferraria foliosa. A, plant; B, one style branch and anther, lateral view; C, anther with free part of filament, adaxial side; D, style branches and anthers as seen from above; E, outer (left) and inner (right) perianth segments; F, longitudinal view of perianth claws, pistil and stamens; G, transverse section of middle of leaf; H, transverse section of upper part of leaf; a, anther; n, nectary; s, stigma.

—3218 (Clanwilliam): Otterdam (-AB), *Compton* 24162 (NBG, BOL); Soutpansklipheuwel, *Stirton* 6081 (STE); Near Verlorevlei, Elands Bay (-AD), *Lewis* 2301 (SAM); Verlorevlei, *Leighton* 156 (BOL), *Compton* 15063 (NBG); NE side of Verlorevlei at Matjiesgoed Drift, *Pillans* 8127 (BOL); Sandy coast Elands Bay, *Pillans* 8095 (BOL), *De Vos* 2318, 2365 (STE); 2 mls from Elands Bay, *Barker* 6377 (BOL); Near Elands Bay, *Lewis* SAM 60869 (PRE); \pm 10 km S van Elandsbaai, pad langs Yskortreinspoor, *Botha & Coetzee* 1712 (PRE).

This species is closely allied to both *F. crispa* and *F. schaeferi* and could perhaps have been a parent species of these polyploid species. In geographical range it occurs between the areas of these polyploids, overlapping *F. crispa* in the latter's northernmost range, and separated from *F. schaeferi* by a distance of about 80 km; but as the flora of the west coast has not been investigated fully, this interval is probably much less.

F. foliosa differs from *F. crispa* firstly in being diploid, secondly in its shorter, more glaucous, horizontally spreading leaves with wider, inflated leaf sheaths and short unifacial blades. The flowers are similar in their stamens and pistils and almost similar in their nectaries. The perianth resembles the dark flowered specimens of *F. crispa*.

The leaves of *F. foliosa* differ from *F. schaeferi* in their larger, bifacial sheaths and shorter unifacial blades, and in having a smaller amount of water-storing tissue; the flowers differ in the former having a longer, darker perianth with longer tapering segments, a shorter, erostrate ovary, and acuminate style branches.

Miller's (1759a) figure 280 is perhaps this species, as to habit, but not as to flower shape and colour (pale sky-blue).

3. *Ferraria crispa* Burm., Nova Acta Acad. Caes. Leop-Car. 2: 199 (1761); Moore, in Bailey 19: 110 (1974). *Iconotype*: Burman l.c. t.3 f.1.

Plants 200–500(–800) mm tall. *Corm* almost symmetrical, depressed globose, or irregular, 15–30(–40) mm diam. *Stem* 150–300(–500) mm long, often rather stout, wholly or partly hidden by leaf sheaths. *Cataphylls* 2–3, often mottled with red. *Foliage leaves* numerous, lower leaves distichous, suberect or slightly spreading, 150–300(–800) mm long, with sheath to 15 mm wide (folded), with narrow, pale or often reddish spotted margins and a long unifacial lamina 5–12 mm wide, thickened in the middle with a prominent midrib, narrowing to an acute or obtuse and mucronulate, or slightly incurved tip; upper leaves shorter, slightly spreading, largely sheathing. *Cymes* numerous, 2-flowered, rarely with 3 flowers. *Spathes* slightly keeled towards their tips, subacute or subobtuse, cuculate, outer 30–45 mm long with narrow, pale or reddish-brown spotted margins, inner 50–65 mm long, with wider colourless margins. *Flowers* 45–50 mm long, with an unpleasant putrid odour, dark brown, maroon or almost black (nearest RHS 200A)

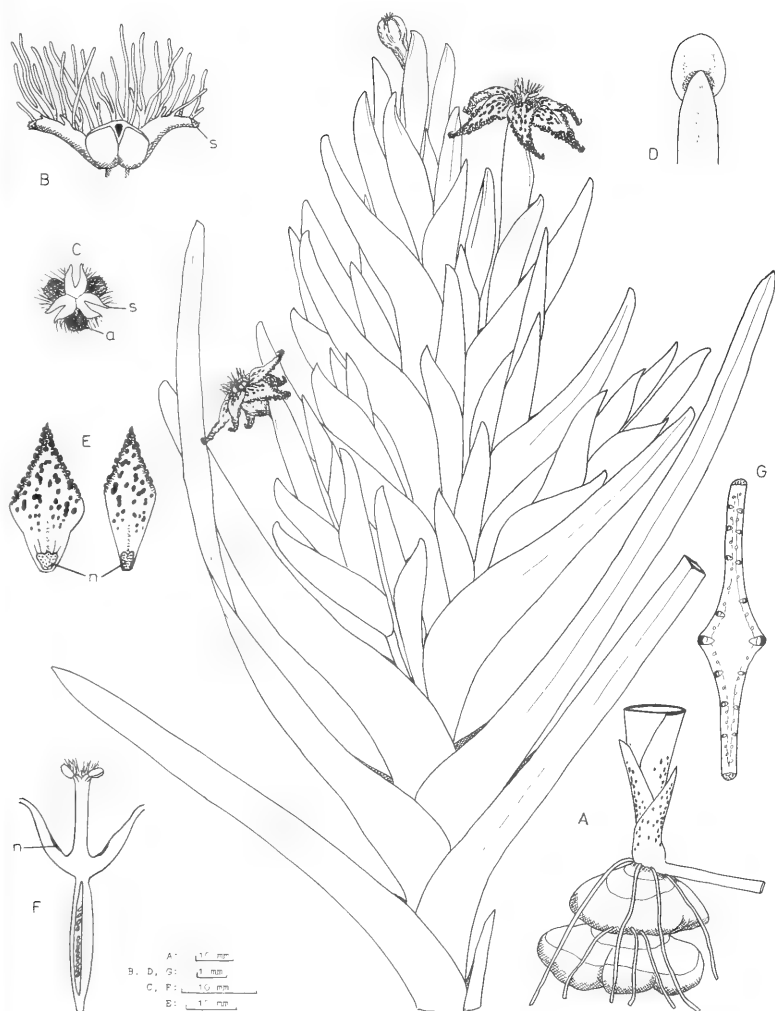


FIG. 19.

Ferraria crispa subsp. *crispa*. A, plant; B, one style branch and anther, lateral view; C, style branches and anthers seen from above; D, anther and free part of filament, adaxial view; E, outer (left) and inner (right) perianth segments, of spotted colour variation; F, base of flower; G, transverse section of leaf blade; a, anther; n, nectary; s, stigma.

often with pale lines and blotches, or cream to pale yellow and variously striped and blotched with dark brown or maroon, and with brownish-green margins. *Perianth claws* forming a widely bell-shaped cup 8–10 mm deep, 10–15 mm diam. at the rim, with narrow slits between the claws; *nectaries* 2–3-lobed, concave, 1–2 mm above the claw bases, $2-3 \times 3-6$ mm, on the outer segments wider than long, almost black with a few pale spots, or pale with dark spots; *segments* acuminate, outer segments 25–30 \times 10–17 mm, often eared above the claws, inner 22–27 \times 6–10 mm. *Filament tube* 6–8 mm long, reddish brown or mottled, the free upper portions 2–3 mm long; *anthers* horizontal, with parallel thecae, at first 4.5–6 mm long, later 2–2.5 \times 2 mm, often black on the backs, with orange pollen. *Ovary* 15–25(–30) mm long, 1.5–2 mm diam. at the top, not rostrate, but the top 5–7 mm without ovules; *style* 7–9 mm long, the branches 3–4 mm long, deeply cleft into two slender tapering, curved, sideways spreading arms, the fimbriae in a dense tuft, 3–4 mm long, mottled; *stigmas* minute, terminal on the style arms. *Capsules* ellipsoid 17–25 mm long, with a pointed erostrate tip; *seeds* 2.5–3 mm diam., golden brown, with shiny, wrinkled testa.

Chromosome numbers: $2n = 40, 60$.

Flowering period: July to October. Each flower remains open for one day only.

Distribution: A predominantly south-western lowland species occurring from Lamberts Bay and Clanwilliam to the Cape Peninsula, Bredasdorp and Mossel Bay, with inland outliers to the Cedarberge, Ceres, Oudtshoorn and Willowmore; in sand or sandy loam.

F. obtusifolia, known only from Sweet's drawing and description, is probably this species. Its flower structure and obtuse leaves are typical of both *F. crispa* and *F. foliosa*. It agrees, however, more with *F. crispa* than with *F. foliosa* in its more erect, not horizontally spreading leaves, with narrow sheaths which are spotted with red towards the base of the shoot, and in its flower cup which is striped inside—a feature occurring in some specimens of *F. crispa*, but not, as far as known, in *F. foliosa*.

F. vandermerwei from Swellendam is this species. The ovaries of the type specimen were found to be not 3 cm long and rostrate as described by L. Bolus, but only 25 mm long, with the top 7 mm sterile, as often occurs in *F. crispa*.

Miller (1758b, 1768) misidentified the two species described by Burman (1761); he regarded *F. fimbriata* Burm. as *F. undulata*, and named *F. crispa* Burm. *F. ensiformis*.

Two subspecies are now recognised which differ in geographical distribution, chromosome numbers, and to some extent in flowering period and size of certain floral organs. Several of the older herbarium specimens which have no laid out flowers and which were collected from areas intermediate between the known habitats of the two subspecies, could not be distinguished with certainty.

The subspecies occurring near the Cape is probably the one described by Burman; this is therefore regarded as the typical subspecies.

KEY TO DISTINGUISH THE SUBSPECIES

Perianth cup ca. 10 mm deep, 12–15 mm diam. at the rim; inner segments ca. 10 mm wide (rarely only 8 mm); from Saldanha Bay towards the south and east. a. subsp. **crispa**
 Perianth cup ca. 8 mm deep, ca. 10 mm diam. at the rim, inner segments 6–7 mm wide; distribution mainly in the Clanwilliam district and towards Piketberg. b. subsp. **nortierii**

a. subspecies **crispa**

Ferraria crispa Burm., Nova Acta Acad. Caes. Leop.-Car. 2: 199 (1761); Moore, in Bailey 19: 110 (1974).

F. undulata L., Sp. Pl. ed. 2, 2: 1353 (1763), nom. superfl., & Syst. Nat. ed. 13: 597 (1770); Jacq., Hort. Vind.: 25 (1770); Cav., Diss. Bot. 6: 343 (1788); Lam., Encycl. Bot. 2: 453 (1788); Curtis, Bot. Mag. 4: 144 (1791); Salisb., Prodr. Stirp.: 42 (1796); Willd., Sp. Pl. 3: 580 (1800); Ker, in Kon. & Sims, Ann. Bot. 1: 242 (1805) & Irid. Gen.: 28 (1827); Ait., Hort. Kew. 2: 136 (1812); Roem. & Schult., Syst. Veg. 1: 495 (1817); Spreng., Syst. Veg. 1: 169 (1825); Eckl., Top. Verz.: 18 (1827); Bak., in J. Linn. Soc. Bot. 16: 106 (1877) & Handb. Irid.: 73 (1892) & in Fl. Cap. 6: 30 (1896); Lewis, in Adams. & Salter, Fl. Cape Penins. 224 (1950) & in Flow. Plants S. Afr. 33: 1316 (1959); non Miller 1768.

Moraea undulata Thunb., Diss. Moraea p. 14 & 17 (1787) & Prodr.: 11 (1794) & Fl. Cap.: 279 (1807) & p. 72 (1823).

Ferraria undata Wännman, Fl. Cap. 370 (1759), nom nud.

F. ensiformis Miller, Gard. Dict. ed. 8 (1768).

F. punctata Pers., Syn. Pl. 1: 50 (1805).

F. obtusifolia Sweet, Brit. Fl. gdn. ser. 1, 2 t.148 (1826), *iconotype*; Bak., in J. Linn. Soc. Bot. 16: 106 (1877) & Handb. Irid. 73 (1892) & in Fl. Cap. 6: 31 (1896).

F. major Eckl., Top. Verz.: 18 (1827), nom. nud.; Nordenstam, in J. S. Afr. Bot. 38: 295 (1972) pro syn.

F. vandermerwei L. Bol., in S. Afr. Gard. 22: 276 (1932). *Type*: Cape, near Swellendam, Van der Merwe BOL 20168 (BOL, holo).

[*Flos indicus e violaceo fuscus* . . . Ferrari, Fl. Cult. 168 & t.171 (1646). *Gladiolus indicus e violaceo fuscus* . . . Morison, Hist. 2: 344, S.4. t.4, f.7. (1680). *Narcissus indicus flore saturate purpureo* . . . Rudbeck, Elys. 2, t.49 f.9 (1701). *Iris stellata cyclamine radice pullo flore* . . . Barrelier, Ic. 1216 (1714)]

Icones: Burman 1761 t.3 f.1, *iconotype*; Jacquin 1770 t. 63; Curtis's bot. Mag. t.144 (1791); Redouté 1803 t.28; Kidd 1950 t.53.2; Rice & Compton 1950 t.191.2; Mason 1972 t.25.2; Flow. Plants S. Afr. 33 t.1316 (1959); this work Figs 19, 12, 5, 6.

Leaves somewhat glaucous. *Perianth cup* ca. 10 mm deep, 12–15 mm diam. at the rim; *inner segments* ca. 10 mm wide (rarely only 7–8 mm). *Anthers* in bud 6 mm long, shrinking to 2.5 mm; *pollen* averaging 130 μ m in length. *Ovary* 20–25 mm long, 3–3.5 mm diam.

Hexaploid: (2n = 60).

Flowering period: usually September to October, sometimes from August.

Distribution: Over more than 400 km from Saldanha Bay to the Oudtshoorn and Willowmore districts.

This subspecies probably originated from the tetraploid subspecies, after hybridising with a diploid, perhaps *F. foliosa*, which occurs within the range of the tetraploid.

CAPE—3217 (Vredenburg): Sandy banks north of Saldanha Bay (-DD), *Hutchinson* 285 (K).

—3218 (Clanwilliam): Prope ostium flumen Berg River (-CC), *Bolus* 6301 (BOL, PRE).

—3219 (Wuppertal): Warm Bath, Citrusdal (-CA), *Bolus* BOL 31222 (BOL).

—3317 (Saldanha): Danger Bay (-BB), *Hall* 759 (NBG); Baviaanskop, Saldanha (-BB), *De Vos* 2323 (STE).

—3318 (Cape Town): Langebaan, Saldanha Bay (-AA), *Lewis s.n.*, *Leighton & Lewis s.n.*, Sept. 1932 (BOL); Papkuilfontein, Darling (-AD), *Godfrey* PRE 28597; Between Darling & Mamre, *L. Bolus s.n.* 5 Aug; Near Darling, *Lewis* 1050 (SAM); Burgherspost, Mamre (-BC), *De Vos* 2324 (STE); Mamre Hills (-CB), *Barker* 3832 (NBG); Fifth gate to Gansekraal, *Barker* 2002 (NBG); Lions Head (-CD), *Lewis* 42 (SAM), *Barnard* NBG 167/45; Cape Town, *Marloth* 7242 (PRE), *Prior* PRE 35776; Mowbray, *Walters* 11 (PRE); Milnerton, *Lewis* 73 (SAM); Slopes Table Mt, *Lewis* 1604 (SAM), 2326 (SAM); Claremont, *French* SAM 12745; Camps Bay, *Thode* 9217, 9220 (STE); Robben Island (-CD), *Walgate* 496 (NBG); Bloubergstrand-Melkbosstrand, *De Vos* 76/43 (STE); Camps Bay, Lower Blinkwater Ravine, *Cassidy* 29 (NBG); Spieka, Klipheuwel (-DA), *Thompson* 2617 (STE); Dassenberg, *Pillans* 6844 (BOL); Jonkershoek, farm Waterfalls (-DD), *Oliver s.n.* Aug. 1974 (STE); Prom. b. Spei, *Thunberg* (S).

—3319 (Worcester): Mostertshoekberg (-AD), *De Vos* 2383 (STE); Hex River Pass (-BC/D), *Barker* 7454 (NBG); Karooport (-BC), *Ross-Frames* BOL 20073.

—3320 (Montagu): Kogmanskloof (-CC), *Lewis s.n.* Sept. 1935 (BOL).

—3322 (Oudtshoorn): Between Avontuur & Oudtshoorn, Diep River (-DA), *Hunt* NBG 2052/33 (BOL); Meiringspoort, Swartberge (-BC), *Loubser* sub *De Vos* 2351 (STE).

—3323 (Willowmore): Georgida (-AD), *Fourcade* 4411 (STE).

—3418 (Simonstown): Fish Hoek (-AB), *Marloth* 9409 (PRE); Hout Bay, *Dodd* 1758 (BOL); Strandfontein (-BA), *Compton* 13705 (NBG), *Taylor* 8173 (STE); Faure, dunes S of Kramat, *Jordaan* 666 (STE); Cape Flats, *Rogers* 16967 (Z); Rooi Els (-BD), *Parker* 4374 (K, NBG, BOL).

—3419 (Caledon): Hermanus Botanical Garden (-AC), *Jeppe* PRE 15513; Hermanus, *Du Plessis* STE 19725, *Beyers* SAM 60143, *Rogers* 26567 (PRE), 26496 (Z); Near Hermanus, *Ross-Frames* NBG 2339/30 (BOL); Hermanus, rocky sandy

places by coast, *Gillett* 22 (STE); Kleinmond, *De Vos* 2360 (STE); Danger Point, *Lewis* 2747 (SAM).

—3420 (Bredasdorp): Near Swellendam (-AB), *Van der Merwe* BOL 20168; Malagas (-BC), *Ross Frames* BOL 20074; Arniston (-CA), *Chamberlain* 81 (BM); Springfield Estate, *Stokoe* SAM 60185; 5–8 km N of Struisbaai (-CC), *De Vos* 2382 (STE).

—3421 (Riversdale): *Albertinia* (-BA), *Muir* 4618 (SAM); *Albertinia* common-age, *Muir* 5479 (PRE); Ystervarkpunt between Gouritzmond & Stilbaai (-BC), *Rycroft* 3119 (NBG); The Fisheries (-BD), *Acocks* 21567 (K, PRE); 1 ml N of Gouritz River Mouth, *Mauve* 4755 (PRE); Vleesbaai, *De Vos* 2293 (STE).

—3422 (Mossel Bay): Mossel Bay (-AA), *Rogers* Oct. 13. 1860 (K); Klein Brak River, *Burchell* 6196 (K).

C.B.S. sine loco: *Sparrman* s.n. (BM); *Oldenburg* 540 (BM).

AUSTRALIA: Hill St., Perth, *Morrison* s.n. 6.9.1898 (BM); East of Perth, *Morrison* 8408 (K).

b. subspecies **nortierii** De Vos, subsp. nov.

A subsp. *crispa* chromosomatum numero tetraploideo, segmentis interioribus perigonii 6–7 mm latis, anthesi praecoci, distributione geographica septentriones distinguatur.

Type: Cape, Clanwilliam, heights north of Elandsbaai, *De Vos* 2366 (STE, holo.).

Leaves green. *Perianth* cup ca. 8 mm deep, ca. 10 mm at the rim; *inner segments* usually 6–7 mm wide. *Anthers* in bud 4.5 mm long, shrinking to less than 2 mm; pollen averaging 110 μ m in length. *Ovary* usually less than 20 mm long, 2.5–3 mm diam.

Tetraploids: (2n = 40).

Flowering period: July to September.

Distribution: Over a small area on the northern border of the range of *F. crispa*, mainly in the Clanwilliam district. In sandy soil, usually amongst rocks.

The flowers usually have a pale yellow perianth with dark brown margins, spots and blotches.

The name of the subspecies is in honour of Dr P. L. Nortier of Clanwilliam, noted physician and biologist.

CAPE—3118 (Vanrhynsdorp): Nardouwsklouf (-DD), *Stokoe* SAM 59837.

—3218 (Clanwilliam): Nortier Expt. Station N of Lamberts Bay (-AB), *Van Breda* 4282 (STE); Otterdam, *Compton* 24162 (BOL); Rocky outgrowth some 2 km N of Lamberts Bay, *De Vos* 2374 (STE); 10 mls from Lamberts Bay towards Graafwater, *Lavis* s.n. Sept. 1934 (BOL); Heights N of Elands Bay (-AD), *De*

Vos 2354, 2366 (STE); Ventersklip N of Verlorenvlei, *Boucher 2831* (STE); Rocky kopje, Graafwater (-BA), *Adamson SAM 39048*; 3 km E of Graafwater, *De Vos 2375* (STE); Between Langevallei & Heerenlogement, *Drège s.n.* (partly, K, S); Pakhuis (-BB), *Leipoldt BOL 20779, BOL 20838*; Kleinkliphuis, Pakhuis, *De Vos 2368* (STE); Clanwilliam, *Schlechter 8584* (BOL, PRE, BM, Z); The Weir, Olifants River valley, *Leighton & Lewis s.n.* Sept. 1932 (BOL); Rocky koppie across Olifants River towards Algeria (-BD), *De Vos 2376* (STE); Olifants River valley, *Lewis s.n.* Sept. 1932 (BOL); Piketberg top (DC), *De Vos 2401* (STE), *Barker 10266* (NBG).

—3219 (Wuppertal): Geelkrans on Vlakrug Farm (-CA), *Van der Merwe 245* (STE).

4. *Ferraria schaeferi* Dinter, in *Reprim nov. Spec. Regni Veg.* **16**: 339 (1920); Sölch, Diss. Univ. München: 128 (1961); Sölch & Roessl, in *Merxm., Prodr. Fl. SWA.* **155**: 4 (1969). Neotype: Schäfer 562 (B).

Type: The holotype, *Schäfer 597*, was probably in Berlin-Dahlem (B). This herbarium still houses a sheet with a single small specimen comprising the top part of a shoot, and with a label: “*Schäfer 562 Ferraria schaeferi* Dtr, Zipfel der Dreikugelberges Klinghardttsgebirge”, and below that, on the same label in pencil, in a different handwriting: “No. 597 Granitberg zw. Prinzenbucht u. Bogenfels”. Probably this specimen is not the holotype but represents *Schäfer 562*, its locality being about 40 km from that of the holotype. This specimen is chosen as neotype in the absence of the holotype.

Plants 200–500 mm tall. *Corm* depressed globose, irregular, subconical, or flattened or concave above, 15–40(–70) mm diam. *Stem* 150–400 mm long, rather stout, foliose, covered with leaf sheaths. *Cataphylls* 2–3, pale, sometimes reddish towards the top. *Foliage leaves* numerous, scimitar-shaped or ensiform, distichous or spirodistichous, spreading or recurved, somewhat succulent, glaucous, up to 300 mm long, with up to 20 mm wide sheaths, narrowing to unifacial laminas to 10 mm wide, somewhat succulent, acute to obtuse; upper leaves horizontal or recurved. *Cymes* generally numerous in a dense cluster, each 2-flowered. *Spathes* with narrow, pale, membranous margins, acute to obtuse, outer 35–40 mm long, inner 50–55 mm long. *Flowers* ca. 50 mm long, rather sweetly scented, yellow with dark brown spots and blotches and with the upper one-quarter and margins dark brown, or dark brown with yellow spots. *Perianth cup* widely bell-shaped, 8 mm deep, 12–15 mm diam. at the rim, with narrow slits between the claws, pale yellow densely dotted with dark brown inside, the claws swollen in the median zone towards their bases; *nectaries* bilobed or bipartite, somewhat concave, 3 × 3–4 mm, brown dotted, 1–2 mm above the bases of the claws; *segments* almost rhomboidal, acute to acuminate, outer segments ca. 25 × 12 mm, inner ca. 22–24 × 9–10 mm. *Filament tube* ca. 7–8 mm long, brown streaked, the upper free portions 2–3 mm long; *anthers* with parallel thecae, at

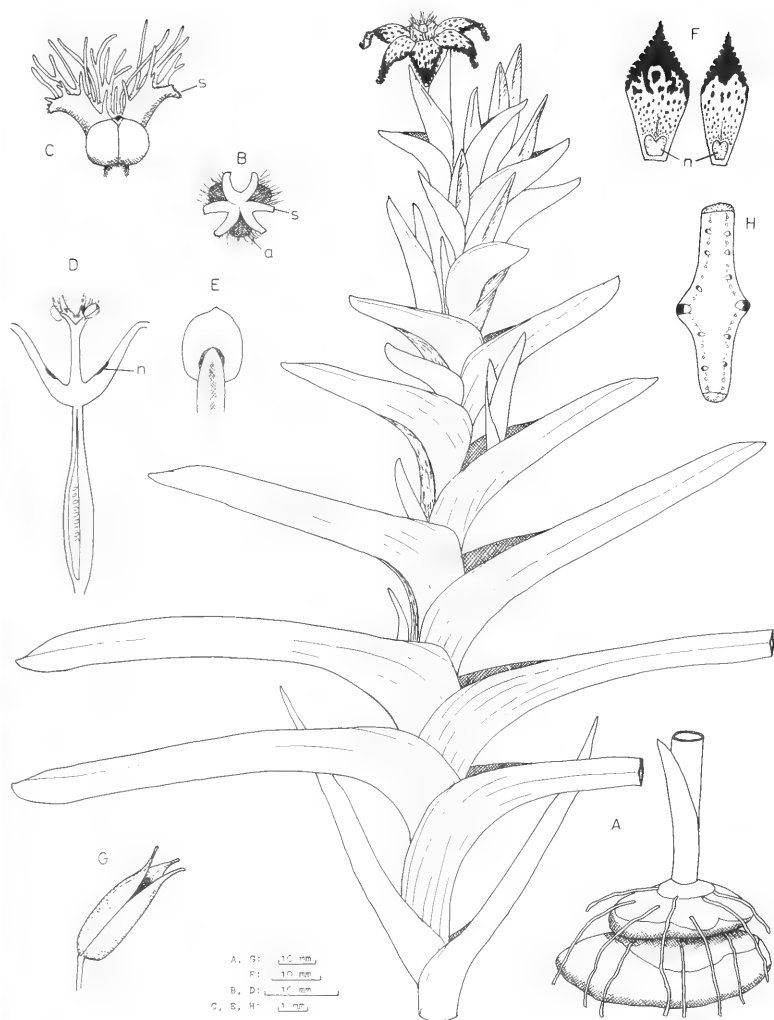


FIG. 20.

Ferraria schaeferi. A, plant; B, style branches and anthers, seen from above; C, one style branch and anther, lateral view; D, base of flower, longitudinal view; E, anther and free part of filament, adaxial view; F, outer (left) and inner (right) perianth segments; G, capsule; H, transverse section of leaf blade; a, anther; n, nectary; s, stigma.

first 5 mm long, later 2.5×2 mm, dark on the backs; pollen brownish-yellow to orange. Ovary triquetrous, ca. 25 mm long, with a slender rostrum ca. 8 mm long; style 8–9 mm long, the branches 4 mm long, cleft halfway down, with curved sideways spreading truncate arms, fimbriae sparse, 2–5 mm long, dark brown or blotched with yellow; stigmas small, terminal. Capsules ellipsoid, 25–35 mm long, with pointed, shortly rostrate tip; seeds 3–4 mm diam., shiny, golden brown, angled by pressure.

Chromosome number: $2n = 40, 60$.

Flowering period: August to September. Each flower remains open for one day.

Distribution: Sparsely distributed over a wide part of the arid northernmost winter rainfall region, from northern Namaqualand to the southern Namib near Lüderitz, and from the coast to the Buchberge and Haalenberg ca. 40 km inland; mainly in deep coastal sand.

NAMIBIA—2615 (Lüderitz): Lüderitzbucht (-CA), *Knobel* SAM 12783; Roadside opposite Haalenberg (-CB), *De Vos* 2393 (STE); Opposite Elizabeth Bay (-CD), *De Vos* 2379 (STE).

—2715 (Bogenfels): Pomona (-AB), *Merxmüller & Giess* 28423 (M); Granitberg near Pomona, *Marloth* 5249 (PRE); Granitberg zw. Prinzenbucht u. Bogenfels, *Schäfer* 597 (B?); Near Schwartz Klippe (-AD), *Kinges* 2683 (M); Klinghardtsgewirge (-BC/D), *Schäfer* 562 (B); Wasserschlucht i.d. Buchbergen (-DD), *Dinter* 6584 (BM).

CAPE—2916 (Port Nolloth): Port Nolloth (-BB), *Galpin & Pearson* 7447 (K); Muisvlak (-BB) *De Vos* 2394 (STE); 10 km from Port Nolloth towards Steinkopf (-BD), *De Vos* 2392 (STE).

—2917 (Springbok): Grootmis, sanddune (-CA), *De Vos* 2391 (STE).

This species has also been found by J. Coetzer of the Consolidated Diamond Mines at Swartberg near Grillental (-Bogenfels -AB) and at Oranjemund (Bogenfels -CD). It is closely related to *F. crispa* and *F. foliosa*, and differs in the possession of a shortly rostrate ovary, minutely truncate style arms and flowers sweetly scented, and from the former also in its more glaucous, more succulent, spreading leaves with shorter unifacial upper part, and flowers with larger brown blotches on the perianth. It further differs from *F. foliosa* in flower colouring and shorter perianth segments. Its leaves resemble those of *F. foliosa* and this diploid species is probably one of its parents. The two species are separated by an interval of about 80 km; but as the west coast has not been investigated fully, the interval is probably much narrower.

5 *Ferraria densepunctulata* De Vos, spec. nov.

Caulis 80–330 mm longus, internodiis inter vaginas foliorum partim manifestis. *Folia* inferiora suberecta, laminis compresso-cylindraceutis, ad 5 mm diam.,

subacutis vel subobtusis, vaginis 5–8 mm latis; folia superiora breviora, fere horizontaliter patentia, vaginis latoribus, apicibus interdum incurvatis. *Cymae* plures, biflorae. *Spathae* marginibus membranaceis, angustis, rubris vel pallidis, spatha exterior 30–40 mm longa, interior 40–50 mm longa, obtusa vel aliquantum cuculata. *Flores* ca. 35–45 mm longi, fere inodorati, segmentis exterioribus differentibus ab interioribus amplitudine et forma et notis. *Perigonium* unguibus cupulam late campanuliformem facientibus, rimis inter ungues, *nectariis* bilobis vel bipartitis, nitidis, 2–7 mm supra bases unguum positis; *segmenta* cinerea vel e cinereo viridia, marginibus undulatis crispulatisque, segmenta exteriora dense punctulata, unguibus 7–10 mm latis, segmenta interiora macula grandi vinacea vel purpurea ornata, unguibus ca. 2 mm latis in dimidio inferiore. *Tubus filamentorum* 8–10 mm longus, partibus liberis superioribus 2–3 mm longis; *antherae* thecis parallelis, horizontales. *Ovarium* interdum exsertum, 12–15 mm longum, eros-tratum; *stylus* 10–12 mm longus, ramis bifidis, brachiis tenuibus curvatis, laterale-patentibus, fimbriis erectis 5–8 mm longis ramosis; *stigmata* ut in *F. crispa*. *Capsula* ellipsoidea vel ovoidea, erostrata; semina testa rugosa. Chromosomatum numerus $2n = 20$.

Type: Cape, Clanwilliam, Elandsbaai, Loubser sub *De Vos* 2317 (STE, holo.).

Plants 120–350 mm tall. *Corm* almost symmetrical, depressed globose to almost disc-shaped, saucer-shaped or sometimes pyramidal, to 50 mm diam. *Stem* 80–330 mm long, internodes partly visible between leaf sheaths. *Cataphylls* 2, often dark reddish-purple towards the tip. *Foliage leaves* few, usually distichous, bright green or sometimes with a slight bloom, lower 1–4 leaves suberect, 100–250 mm long, with laminas compressed cylindrical, up to 5 mm diam., subacute to subobtuse, sheaths 5–8 mm wide with narrow, pale or reddish-brown, membranous margins; upper leaves shorter, spreading almost horizontally, with wider sheaths and tips sometimes incurved. *Cymes* several, 2-flowered. *Spathes* with narrow reddish or pale membranous margins; outer 30–40 mm long, acute, inner 40–50 mm long, obtuse or with a somewhat cuculate tip. *Flowers* ca. 35–45 mm long, almost odourless, with the outer perianth segments differing from the inner in size, shape and markings. *Perianth claws* forming a widely bell-shaped cup 8–10 mm deep, 15–20 mm diam. at the rim, with slits between the claws; *nectaries* bilobed or bipartite with two concave hollows, $1-2 \times 3-4$ mm, pale green or yellowish-green, shiny, 2–4 mm above the bases of the outer claws and 5–7 mm above the bases of the inner; *segments* pale grey (RHS 196A, D) or greyish-green, with undulate and minutely crisped margins, acute or obtuse; outer segments densely spotted with small maroon or purple dots, $28-30 \times 10-15$ mm, the claws 7–10 mm wide spotted, inner segments with a large maroon or dark purple blotch, $25-27 \times 7-10$ mm, with claws ca. 2 mm wide in the lower half. *Filament tube* 8–10 mm long, the free upper portions 2–3 mm long; *anthers* with

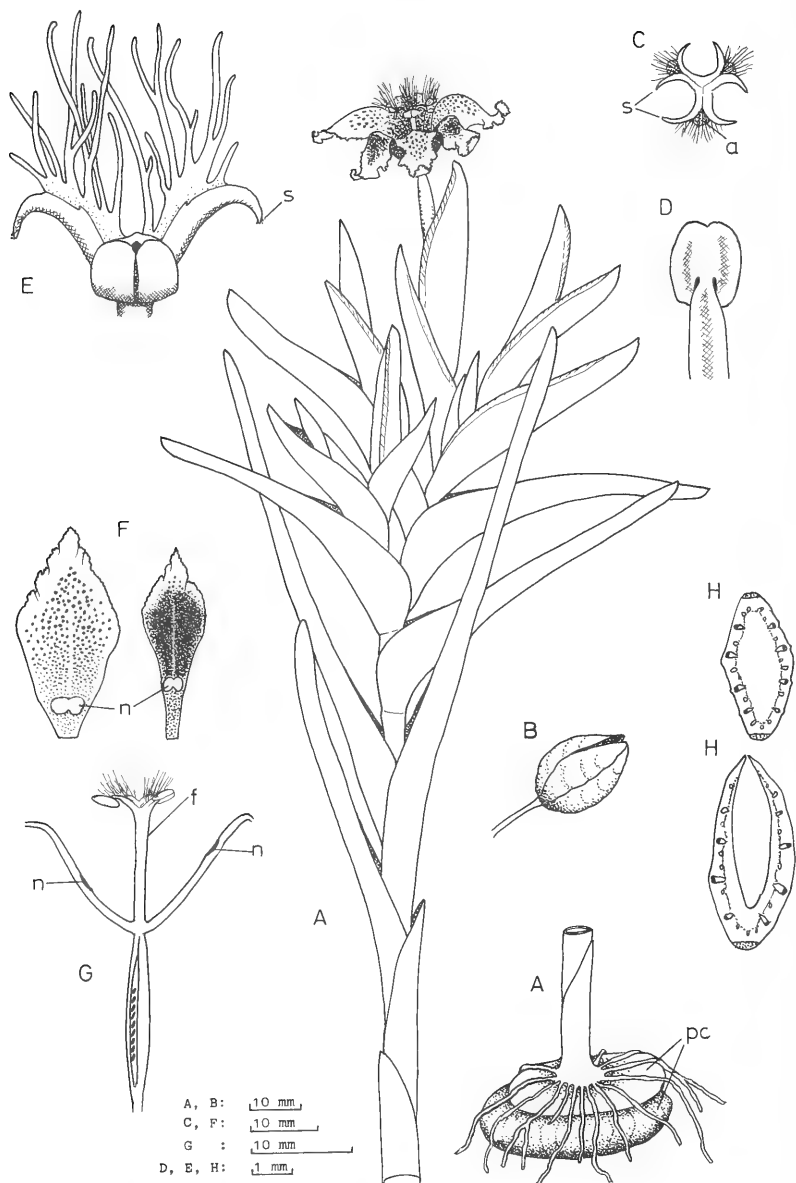


FIG. 21.

Ferraria densepunctulata. A, plant, *De Vos 2317*; B, capsule; C, top view of style branches and anthers; D, anther and free part of filament, adaxial view; E, one style branch and anther, lateral view; F, outer (left) and inner (right) perianth segments; G, base of flower, longitudinal view; H, transverse sections of leaf, upper half (above) and middle of leaf (below); a, anther; f, filament tube; n, nectary; s, stigma.

parallel thecae, at first 4–5 mm long, later 2×1.5 mm, horizontal, pollen orange to deep yellow. *Ovary* sometimes exserted, 12–15 mm long, not rostrate; *style* 10–12 mm long, the branches cleft about halfway down, with slender, acuminate, curved, sideways spreading arms and erect branched fimbriae 5–8 mm long; *stigmas* as in *F. crispa*. *Capsule* ellipsoid or ovoid, 15–25 mm long, not rostrate; *seeds* 3 mm diam., golden brown, testa wrinkled.

Chromosome number: $2n = 20$.

Flowering period: May to July. Flowers remain open for two days.

Distribution: Found over a distance of 120 km within 15 km from the coast, from Lamberts Bay to Langebaan, in coastal sand.

CAPE—3218 (Clanwilliam): Langdam near Lambertsbaai (-AB), *De Vos* 2298, 2342 (STE); Elandsbaai naby brug (-AD), *Loubser* 2240, 2192, *Loubser* sub *De Vos* 2317 (STE); Elands Bay near school, *Pamphlett* 98 (NBG).

—3318 (Cape Town): Langebaan hills behind hotel (-AA), *Leipoldt* 3844 (BOL).

This is the earliest flowering of the Cape *Ferraria* species. The flowers appear about a month after the appearance of the leaves and develop before the formation of the new corm. In this respect it resembles *F. glutinosa*.

In its fresh state it is readily distinguished by its pale greyish perianth with the outer segments densely spotted with small dark purple or maroon dots and the inner segments with a large purple or maroon blotch above the claws and sometimes also with faint dots. Other distinctive features are the parallel anther lobes, ovary without a rostrum, and the pale green, bilobed or bipartite nectaries situated several millimetres above the bases of the claws.

F. densepunctulata differs from other members of section *Ferraria* in its narrow, compressed cylindrical lower leaves, its early flowering period, and its flowers which have the outer perianth segments different from the inner in size, shape and markings, and which remain open for two days.

The species resemble *F. ferrariola* in its partly visible stem and short, horizontally spreading upper leaves with wide leaf sheaths; the lower foliage leaves are, however, shorter, more stiff, suberect and slightly wider than in *F. ferrariola*, and the flowers differ in several respects e.g. parallel anther lobes, exserted ovary and spotted perianth.

III SECTION MACROSCYPHAE (Bak.) De Vos emend.

Macroscyphae Bak., in J. Linn. Soc. **16**: 106 (1877), as species group.

Stem much or sparsely branched, densely foliose or with few leaves. *Cymes* 2-flowered. *Perianth claws* forming a narrow funnel-shaped, or sometimes a bell-shaped, cup (*F. divaricata*), (8–)10–15(–20) mm deep, usually with overlapping margins (except in *F. ferrariola*). *Nectaries* usually very small, basal on the claws or 1–3 mm above the bases of the inner claws. *Anthers* with thecae generally divaricating after dehiscence. *Ovary* with a sterile rostrum (8–)10–20

mm long; style with widened, flattened bifid branches; stigmas slightly elongated, grooved or flattened, on the margins of the flat style branches below tufts of fimbriae. Capsule ellipsoid, with a persistent rostrum.

Chromosome numbers: $2n = 20, 40$.

Type species: Baker (l.c.) placed only two species in his group *Macroscyphae*, namely *F. divaricata* and *F. ferrariola*, erroneously equating the latter with *F. antherosa*. *F. divaricata* Sw. has therefore been chosen as type species.

Distribution: In the western coastal, as well as inland districts, throughout Namaqualand to the south-western Cape districts (but not in the Cape Peninsula) and eastwards to Oudtshoorn, with extensions to the western Great Karoo and the Kalahari.

This section comprises five species, three of which, namely *F. uncinata*, *F. kamiesbergensis* and *F. brevifolia*, are closely related. *F. divaricata* is a large polymorphic species with several subspecies, one of which is tetraploid. *F. ferrariola* is intermediate between this section and section *Ferraria*. Anatomically the leaves usually have their large veins about equal in size, so that a midrib is usually not evident. Epidermal papillae occur in several species. A layer of parenchyma is often present between the sclerenchyma of the veins and the epidermis. The pollen exine has a finer and more uniform reticulation than in section *Ferraria*.

6. *Ferraria ferrariola* (Jacq.) Willd., Sp. Pl. ed. 4, 3: 581 (1800); Ait., Hort. Kew. 4: 136 (1812) excl. syn. Ker; Roem. & Schult., Syst. Veg. 1: 496 (1817) excl. syn. Ker; Spreng., Syst. Veg. 1: 169 (1825); Ker, Irid. Gen.: 28 (1827) excl. syn. Ker; Klatt, in Abh. Naturf. Ges. Halle 15: 386 (1882) & in Dur. & Schinz, Consp. Fl. Afr. 5: 156 (1895) excl. syn. Ker; Bak., in J. Linn. Soc. Bot. 16: 106 (1877) excl. syn. Ker; non Ecklon, 1827.

Moraea ferrariola Jacq., Coll. Bot. 4: 141 (1790) (basonym) & Hort. Schoenbr. 4: 24 & t.450 (1804), *iconotype*.

F. viridiflora Andrews, Bot. Rep. 4: 285 (1803), *iconotype*.

F. viridis Ker, in Curtis's bot. Mag. 20: 751 (1804), pro syn., orth. error for *F. viridiflora* Andrews.

F. minor Pers., Syn. Pl. 1: 50 (1805).

F. longa Barnes, in S. Afr. Gard. 20: 313 (1930). Type: Cape, Nieuwoudtville, *Ross-Frames* BOL 19207 (BOL, holo.).

? *F. angustifolia* Sweet, Brit. Fl. gdn. sub t.192 (1827), sp. dub., no type found.

Misidentifications: *F. antherosa* Bak., Handb. Irid.: 72 (1892) pro parte & in Fl. Cap. 6: 29 (1896) pro parte; *F. undulata* Klatt, in Linnaea 34: 625 pro parte.

Icons: Jacquin 1804 t.450; Andrews 1803 t.285; S. Afr. Gard. 20: 313 fig. A (original coloured drawing in BOL); this work Figs 22, 1, 5, 13A.

Plants 150–500(–600) mm tall, heterophyllous. Corms obliquely ellipsoid, in

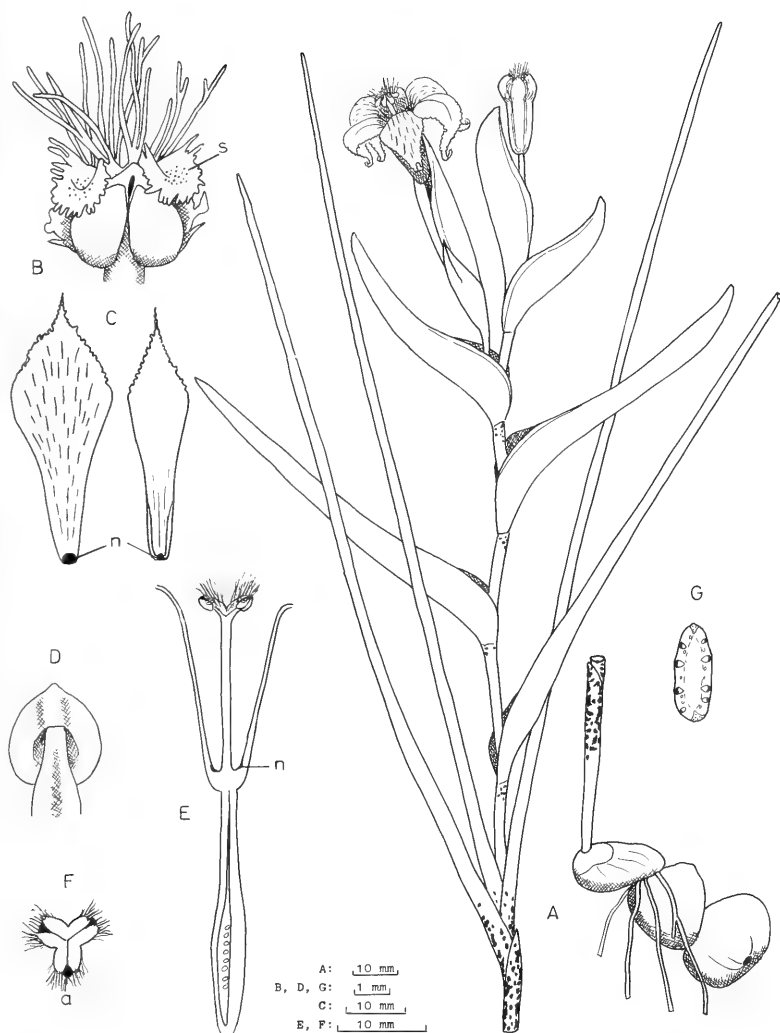


FIG. 22.

Ferraria ferrariola. A, plant; B, one style branch and anther, side view; C, outer (left) and inner (right) perianth segments; D, anther and free part of filament, adaxial view; E, base of flower, longitudinal view; F, top view of style branches; G, transverse section of leaf blade, a, anther; n, nectary; s, stigma.

an oblique row, 20–40 mm diam. *Stem* erect or slightly flexuose, 100–300 (–400) mm long, slender, often sparsely branched in the upper part, partly visible between the leaf sheaths. *Cataphylls* generally 2, reddish or densely red or purple spotted towards the top. *Foliage leaves* several, lower leaves 3–4, compressed cylindrical or subterete, acute, 150–450 mm long, 1–5 mm wide, with narrow, often red spotted sheaths; upper leaves shorter and wider, widely patent, sheath wide with narrow pale membranous margins, narrowing to an incurved tip. *Cymes* 1 to several. *Spathes* with narrow, pale or reddish membranous margins, outer spathe 30–45 mm long, often somewhat spreading, with an acute, incurved tip, inner 50–65 mm long, erect. *Flowers* 50–80 mm long, sweetly almond or aniseed scented, greenish-white or pale greenish-yellow to pale greenish-blue. *Perianth cup* narrowly funnel-shaped, 17–20 mm deep, 10–12 mm diam. at the rim, with slits between the narrow claws; *nectaries* very small, green, at the base of the claws; *segments* with attenuate tips, margins slightly crisped and pale greenish-grey; outer segments 35–40 mm \times 12–18 mm, striate with numerous short dark lines, inner segments narrower, 30–37 mm \times 7–10 mm, not or faintly striate. *Filament tube* 12–20 mm long, pale, the free upper portion 2–4 mm long; *anthers* at first 5 mm long, later 3 mm, lobes at first parallel, later slightly divaricate at the bases, with yellow to orange-yellow pollen. *Ovary* 15–30 mm long, with a rostrum 8–20 mm; *style* 15–25 mm long, the branches 5–6 mm wide, flat, shallowly bifid, fimbriae pale, ca. 5 mm long; *stigmas* flattened, pale, bent over the anther tips. *Capsule* ellipsoid, 20–35 mm long, rostrate; *seeds* 3–4 mm diam., with a wrinkled, shiny brown testa.

Chromosome number: $2n = 20$.

Flowering period: June to September. The flowers remain open for 2–3 days.

Distribution: Throughout Namaqualand to Vanrhynsdorp and Clanwilliam, and from the coast to Nieuwoudtville and Pakhuis above the first escarpment, at altitudes up to 700 m. In stony, sandy, or gravelly ground.

CAPE—2816 (Oranjemund): Koeboes, Richtersveld (-BD), *Herre* STE 11861; Flats near Arrisdrift (-DA), *Marloth* 12391 (STE).

—2817 (Vioolsdrif): Richtersveld, *Marloth* 6758 (BOL).

—2917 (Springbok): Steinkopf na Kosies (-BA), *Verdoorn & Dyer* 1861 (PRE); Spektakel hill (-DA), *Barker* 7426 (NBG), *De Vos* 2330 (STE); 2 mls N of Springbok, (-DB), *Barker* 6250 (NBG); 8 km S of Springbok, v.d. *Walt*, sub *De Vos* 2300 (STE); Springbok, *Eliovson* 50 (PRE); Road Modderfontein-Pollyskloof (-DB/DC), *Van Heerden* 21 (BOL); In lapidosis prope Modderfontein (-DB), *H. Bolus* 6624 (BOL); Between Brakwater & Komaggas (-DC), *Hall* 159 (NBG); Voëlklip, rocky clefts (-DD), *Eliovson* 50 (PRE).

—3017 (Hondeklipbaii): Kamieskroon (-BB), *Marloth* 13268 (PRE), *Compton* 11110 (NBG); Skilpad near Grootvlei, *Lewis* 4993 (SAM), *Barker* 8619 (NBG);

Between Garies & Kamieskroon (-BD), *De Vos* 2327 (STE); 8 km NW of Garies (-DB), *Acocks* 19315 (PRE, K).

—3118 (Vanhynsdorp): Mierhofkasteel 12 km SW of Nuwerus (-AB), *Lewis* 2298 (SAM); Koekenaap-Nuwerus road opposite and N of Kliphoek Sta. (-AC), *De Vos* 2371, 2372 (STE); Holrivier (-AD), *Hall* 3730 (NBG); Between Knechtsvlakte & Sandveld, *Leipoldt* 4084 (BOL); 8 km N of Strandfontein (-CA), *De Vos* 2352 (STE); Farm Kliphoek 10 mls E of Doringbaai (-CD), *Hall* 3743 (NBG); Sandkraal (-DA), *Steyn* 435 (NBG); Between Vanhynsdorp & Klawer, *Lewis* 1991 (SAM); Ca. 3 km NW of Klawer towards Vredendal, *De Vos* 2340 (STE); Heerenlogement (-DC), *Esterhuysen* 5594 (BOL); Between Gifberg & Matsikamma, *Leipoldt* 4083 (BOL); Klawer, *Andreae* 401 (PRE); Between Clanwilliam & Klawer, *De Vos* 2346 (STE); The Krantz 6 mls out of Klawer, *Lewis* e.a. NBG 1859/32 (BOL, BM, K); 11 mls S of Klawer, *Lewis* 2299, SAM 60867 (PRE).

—3119 (Calvinia): Nieuwoudtville (-AC), *Ross-Frames* 19207 (BOL); Top Botterkloof Pass (-CB), *Lewis* 1992 (SAM); Between Doringriver & Botterkloof (-CD), *De Vos* 2370 (STE); Botterkloof, *Lewis* 2300 (SAM); Across Doringriver near Botterkloof, *Goldblatt* 432 (BOL).

—3218 (Clanwilliam): Clanwilliam (-AD), *Schlechter* 8597 (BM, K, PRE, Z), s.n. 21.8.96 (BOL); Between Langevallei & Heerenlogement (-BA), *Drège* s.n. (K, partly); De Lille, ft. of Nardouws Pass (-BB), *Van Breda* sub *De Vos* 2294 (STE); Biesiesfontein, *Leipoldt* BOL 20769; Langkraal, *Martin* NBG 1758/37, *Barker* 249 (NBG).

—3219 (Wuppertal): Pakhuis Pass (-AA), *Barker* 10454 (NBG); Pakhuis 2 km beyond turn-off to Bidouw, *De Vos* 2369 (STE); Mountain slopes above Welbedacht (-AB), *Lewis* 5225 (SAM).

Without precise locality: Namaqualand, *Scully* s.n. (K).

F. ferrariola is readily distinguished by its stem which is not completely covered with leaf sheaths, its red or purple spotted basal leaf sheaths, by its heterophylly, the lower leaves being suberect, long and narrow, and the upper ones short, widely spreading with wide sheaths narrowing to short incurved tips, and by pale flowers with the outer segments finely striate with short dark lines. The only species with which the species can be confused is *F. densepunctulata*, from which it differs in flower colouring, rostrate ovary, broadly flattened style branches, and red spotted lower leaf sheaths.

F. ferrariola has some features intermediate between sections *Ferraria* and *Macroscyphae*, such as anthers with lobes which divaricate late and only slightly. As the ovary is rostrate and the stigmas flattened, the species is placed with the latter section. Ker (1804) confused *F. ferrariola* with his *F. antherosa*, citing as synonym *F. viridis* Bot. Rep. t.285, which is an orthographical error for *F. viridiflora* Andrews, a superfluous name for *F. ferrariola*. His error led to the two species being repeatedly confused during the nineteenth century and later.

F. angustifolia Sw., an incompletely known species of which no type has been found, is described as having "very narrow subulate linear leaves and a greenish flower somewhat resembling *F. antherosa*". This is probably *F. ferrariola*, as the latter is widespread and is the only species then known with narrow leaves.

7. *Ferraria divaricata* Sweet, Brit. Flow. gdn. ser. 1, t.192 (1827). *Iconotype* l.c. t.192.

Plants 150–300(–400) mm tall. *Corm* irregular or depressed globose or almost cone-shaped but with a rounded top, 15–30 mm diam. *Stem* 60–200(–300) mm long, covered by leaf sheaths. *Cataphylls* 1–2, largely membranous. *Foliage leaves* numerous, suberect or spreading, distichous, 100–250(–400) mm long, (5–)7–12(–20) mm wide, with sheath as wide as, or slightly wider than the lamina which has an acute, obtuse or incurved, hooked tip, numerous closely spaced veins, rarely a slightly stronger midrib, and smooth margins. *Cymes* few to numerous. *Outer spathes* 35–40(–45) mm long, acute or subacute; inner 55–70(–90) mm long, with wide membranous margins, acute, subobtusate or with a hooded tip. *Flowers* 60–75(–80) mm long, with a sweet, or sharp unpleasant scent, yellow, green, bluish-green, orange-yellow or brown, often with a purplish-blue or greenish median blotch on each segment and sometimes with purplish or greenish spots, the margins concolorous or discolorous. *Perianth* with overlapping claws forming a bell-shaped cup 12–15 mm deep, 13–20 mm diam. at the rim; *nectaries* up to 4×2 mm, often bilobed or rarely 3-lobed, basal or a few mm above the bases of the inner claws; *segments* with concolorous, or brownish or greenish, crisped margins, limbs longer or sometimes shorter than the claws, with acuminate or slender, attenuate tip; outer segments $30\text{--}45\text{--}(50) \times 10\text{--}15\text{--}(20)$ mm, inner $27\text{--}40\text{--}(45) \times 6\text{--}10\text{--}(13)$ mm. *Filament tube* 10–12 mm long, the free upper portions (1.5–)2–4 mm long; *anthers* at first 5–6 mm long, later 2.5–4 mm, with widely divaricate lobes, pollen orange or yellow. *Ovary* 25–35(–60) mm long, with a rostrum 10–12 mm long; *style* 10–16 mm long, branches flat, widened to 4–6 mm, bifid, with dense tufts of pale or dark, often dendroid fimbriae ca. 5 mm long; *stigmas* slightly elongated, grooved, usually on the upper corners of the flat style branches, curved towards the anthers. *Capsule* long ellipsoid, $30\text{--}45\text{--}(50) \times 8\text{--}10$ mm, rostrate; *seeds* ca. 4 mm diam., pale brown to golden brown, wrinkled or sometimes finely reticulate or foveo-reticulate.

Chromosome numbers: $2n = 20, 40$, rarely 30, 50, 60.

Flowering period: End of July to October or November. The flowers remain open for one to two or sometimes three days.

Distribution: The most widely distributed species of *Ferraria* in the R.S.A., occurring from Namaqualand to the Cape Flats and the districts of Ceres, Worcester, Bredasdorp and Oudtshoorn, with outliers to the Great Karoo, southern Namibia and the Kalahari; in sand, sandy shale or gravel.

F. divaricata is a variable, aggregate species distinguished by its large flowers with large, widely divaricating anther lobes, flattened style branches and rostrate ovary. It is further distinguished from other members of section *Macrosicyphae* by its perianth with a bell-shaped cup, wider segments and generally larger nectaries. Variation occurs in flower colouring, shape of perianth segments, size of nectaries, length of ovary rostrum, width of leaves, and also in chromosome numbers.

Ker's figure and description of *F. antherosa* in Curtis's Bot. Mag. t.751 (1804) are undoubtedly the present species. He cited as a synonym *F. viridis*, Bot. Rep. t.285 (an orthographic error for *F. viridiflora* Andrews, which proved to be a superfluous name for *F. ferrariola* (Jacq.) Willd.) The type (icono) of *F. viridiflora* is therefore included in *F. antherosa* and the latter epithet must be rejected as superfluous. Many workers of the nineteenth century, such as Aiton (1812), Roemer & Schultes (1817), Steudel (1840), Klatt (1895) and Baker (1877, 1892, 1896) also regarded the two species as identical, all except Baker treating *F. antherosa* as a synonym of *F. ferrariola*. But these two species are not conspecific, and the present species must therefore be given a legitimate name, which is *F. divaricata* Sweet.

Four subspecies are recognised which differ to some extent in geographical range, flowering period and chromosome numbers. Only slight morphological differences occur between the subspecies, such as the length of the free portion of the filaments, the form and colouring of the perianth, and the sculpture of the seed coat. Furthermore, these morphological differences are often difficult or impossible to observe in older herbarium material; thus some specimens cannot be allocated to the subspecies on morphological grounds, and the only criteria to use are the locality and the flowering period.

All four subspecies occur in the Vanrhynsdorp district, and this area can be considered the developmental centre of the subspecies. Subspecies *divaricata* which occurs from Namaqualand to Vanrhynsdorp, Clanwilliam and in the Karoo, is probably the original form from which the other subspecies are derived. These have spread to the south and south-east.

Evidence of hybridization between subspecies has been found in the form of a triploid (*De Vos* 2389) from the top of the Gifberg, Vanrhynsdorp, with leaves up to 20 mm wide. Subspecies *divaricata* (diploid) and subspecies *australis* (tetraploid) from which this hybrid probably originated, occur at the foot of the mountain.

KEY TO THE SUBSPECIES

- 1 Perianth bright golden yellow; limbs with concolorous margins c. subsp. **aurea**
- 1 Perianth greenish-yellow, bluish-green, yellow-brown to brown; limbs usually with discolorous margins.
- 2 Outer perianth segments usually without spots; free upper portion of filaments usually longer than 2.5 mm; diploids.
- 3 Leaves erect or suberect; flowers largely brown; flowering period (September-) October-November; in deep sand in coastal districts from Strandfontein to Bellville b. subsp. **arenosa**

- 3 Leaves usually spreading, rarely suberect; flowers greenish-yellow to brownish-yellow or bluish-green, the segments usually with a diffuse bluish median zone; flowering period August to September; in gravel or sand, from Namaqualand to Clanwilliam, the Karoo and Kalahari a. subsp. **divaricata**
 2 Outer perianth segments usually with small spots; free upper portion of filaments usually less than 2,5 mm long; polyploids d. subsp. **australis**

a. subspecies **divaricata**

F. divaricata Sweet, Brit. Flow. gdn. ser. 1 t.192 (1827), *iconotype*; Klatt, in Linnaea **34**: 625 (1865–66) & in Abh. Naturf. Ges. Halle **15**: 387 (1882) & in Dur. & Schinz, Cons. Fl. Afr. **5**: 156 (1895); Bak., in J. Linn. Soc. Bot. **16**: 106 (1877) & Hdb. Irid.: 73 (1892) & in Fl. Cap. **6**: 30 (1896).

F. antherosa Ker, in Curtis's Bot. Mag. **20**: 751 (1804), as to description and figure but not to synonym, nom. illeg. (nom. superfl.), & in Kon. & Sims, Ann. Bot. **1**: 242 pro parte (1805); Bak., Hdb. Irid.: 72 (1892) excl. syn. & in Fl. Cap. **6**: 29 (1896) excl. syn.; Pole Evans, in Flow. Pl. S. Afr. **2**: 66 (1922).

Icones: Curtis's Bot. Mag. **20** t.751 (1804); Sweet, Brit. Flow. gdn. ser. 1, t.192 (1827); Flow. Pl. S. Afr. **2** t.66 (1922).

Lower foliage leaves spreading or sometimes suberect, 4–20 mm wide. *Perianth* greenish-yellow, bluish-green or brownish-yellow, the limbs usually with a bluish or purplish median zone, usually without spots, longer to shorter than the claws, tips usually attenuate; nectaries to 3–4 mm long, basal on the outer claws, and basal or up to 3 mm above the inner claw bases. *Filaments* with the upper free portions (2,5–)3–4 mm long. *Seeds* with a rather dull wrinkled testa.

Chromosome number: $2n = 20$.

Flowering period: August to end of September. The flowers remain open for one to two days.

Distribution: Widely distributed from southern Namibia through Namaqualand to Clanwilliam, in the Karoo and the Kalahari; in sand or shale.

NAMIBIA—2716 (Witputs): Namuskluft (-DD) *Giess 12900* (M, PRE, WIND).

CAPE—2817 (Vioolsdrift): 15 km S of Vioolsdrift (-DC) *Giess 14535* (PRE).
 —2820 (Kakamas): Aries (-AA), *Barnard SAM 36065*.

—2821 (Upington): Upington sandveld (-AC), *Mostert 1415* (PRE).

—2822 (Glenlyon): 21 mls SW of Olifantshoek (-BA), *Leistner 2787* (KMG); Langberg, Hay (-DD?), *Hunter 18* (PRE); Doringaar, Hay, *Acocks 571* (PRE, KMG).

—2917 (Springbok): Steinkopf, Kasteelpoort (-BC), *Herre STE(BG) 493* (BOL); Koufontein, nr. Steinkopf, *Herre STE(BG) 3009* (BOL); 21 mls N of Springbok (-BD), *Mauve 4173* (PRE); Steinkopf, *Lewis 5496* (NBG); 25 mls from Okiep on Goodhouse road, *Lewis 5522* (NBG); Between Ratelpoort and Okiep (-BD-DB), *Lewis 5502* (NBG); Between Springbok and Steinkopf, *Van der Schijff 8250* (PRE); Buffels River kloof (-CB-DA), *Lewis 1373* (SAM); !Us se sand (-DA),

Herre STE 11325; Nigramoep, *Wikner* SAM 62780; W foot of Spektakel Pass, *De Vos* 2331 (STE); 28 mls W of Springbok after Spektakelberg, *Thompson* 1049 (STE); Between Brakwater and Komaggas (-DC), *Hall* 158 (NBG); Between Komaggas and Soebatsfontein, *Barker* 6746 (NBG); Komaggas, *Herre* Fl. Hort. S.U.G. 488 (BOL); Between Springbok and Bowesdorp (-DD), *De Vos* 2329b (STE).

—2918 (Gamoep): Near Ratelkraal (-CA), *Barker* 6757 (NBG).

—2919 (Pofadder): Roadside Pofadder to Springbok 6 km (-AB), *Boucher* 2886 (STE).

—2921 (Kenhardt): Kenhardt golf course (-AC), *De Vos* 2395 (STE); Kenhardt, *Van Niekerk* STE 8815.

—3017 (Hondeklipbaai): Soebatsfontein (-BA), *Barker* 3708, 6746 (NBG).

—3018 (Kamiesberg): Stinkfontein, in collibus (-CC), *Schlechter* 11096 sub *F. plumosa* Schlecht. ined. (B, BM, BR, K, S).

—3022 (Carnarvon): Buffelsbout in Central Karoo (-AD), *Burchell* 1599 (K) pro parte, sub *F. atrata* Lod.

—3023 (Britstown): Britstown (-DA), *Mauve* 4133 (PRE).

—3118 (Vanhynsdorp): 2 km on Kliprand rd. E of Nuwerus (-AB), *Hugo* 461 (STE); Between Klawer and Vanhynsdorp (-DA), *Bolus* BOL 23194; Sanddunes 3–4 mls N of Klawer station, *Leipoldt* 4166 (BOL); Vanhynsdorp, *Rood* PRE 1471; 8 km N of Vanhynsdorp, *De Vos* 2332 (STE); 12 km E of Vredendal, *Hall* 3670 (NBG); Gifberg, mountain path from Windhoek, *Phillips* 7760 (NBG); Windhoekwerf onder Gifberg, *De Vos* 2358 (STE); Flats W of Matsikamma (-DB), *Oliver* 4993 (STE); Urionskraal, *Barker* 8581 (NBG); Near foot of Tigerberg about 15 mls E of Vanhynsdorp, *Lewis* 4430 (SAM); Sandkraal, Vanhynsdorp, *Steyn* 432 (NBG); Klawer (-DC), *Maguire* 943 (NBG), *Bolus & Lewis* BOL 31243; Salt River bridge, Vanhynsdorp (-BC), *Acocks* 16432 (PRE).

—3119 (Calvinia): Near Nieuwoudtville (-AC), *Acocks* 14712 (PRE); Nieuwoudtville, *Bolus* BOL 19574; Near river on way to Grasberg, near Nieuwoudtville, *Bolus* BOL 19349; Nieuwoudtville, Klipkoppies lower slopes, *Barker* 9537 (NBG); Between Nieuwoudtville and Oorlogskloof (-AC/D), *Leipoldt* 3841 (BOL); Kareekom, c. 25 mls N by W of Calvinia (-BA), *Leistner* 466 (PRE); Calvinia (-BD), *Schmidt* 135 (PRE); Boklandskloof (Lokenberg N) (-CA), *Acocks* 19736 (NBG); Koedemoefontein near Botterkloof Pass (-CD), *Oliver* sub *De Vos* 2353 (STE); Kareeboomfontein (-DA), *Hanekom* 2412 (PRE).

—3218 (Clanwilliam): Clanwilliam, sandy hill slope (-BB), *Galpin* 10517 (PRE); On the Olifants River and at Villa Brakfontein, 76 (-DB), *Ecklon & Zeyher* s.n. (PRE, Z), PRE 22381.

—3219 (Wuppertal): Pakhuis, 5 km from turnoff towards Bidouw (-AA), *De Vos* 2348 (STE); Bidouw valley (-AB), *Middlemost* 1746 (BOL, NBG); Welbedacht, Bidouw River valley, *Lewis* 2665 (SAM); Matjiesriver, Cedarberg (-AC), *Wagner* 198 (NBG).

This subspecies is distinguished by its usually spreading leaves, perianth segments of diverse shades but not golden yellow, usually without spots, often with a diffuse bluish or purplish median zone above the claws, limbs usually longer than the claws, and by the free portions of the filaments usually more than 2.5 mm long.

Collections from Namaqualand, such as *Herre* sub STE 11325, *Hall* 158 (NBG), *Barker* 6757 (NBG), *Lewis* 5522 (NBG), *Rösch & Le Roux* 583 (PRE), *Giess* 14535 (PRE), etc., differ in their longer, narrow (ca. 4–5 mm wide) linear lower foliage leaves.

Compton 5405 from Wallekraal, Namaqualand (in NBG, but not BOL) comprises two unusual specimens with narrow, spirally twisted leaves. It is nearest this species.

Plants from the Karoo and Kalahari vary somewhat from those of the western districts: they often have glaucous suberect leaves up to 300 mm long and the flowers have very dense tufts of fimbriae; their colour has been recorded as "dark purple, tips of lobes dirty yellow" and "dark grey brown". Specimens from Kenhardt (*De Vos* 2395) show a large purple blotch on each perianth lobe, with the upper part of the lobe brownish-orange. Baker (1892, 1896) misidentified *Burchell* 1599 from Buffelsbout in the Central Karoo, as *F. atrata* Lod., a species with an inadequate description and an incorrectly drawn figure in which the stamens and style fit no species of *Ferraria*. (Loddiges's plant was brought from the Cape by Mr Synnot and is not Burchell's specimen.)

b. subspecies **arenosa** De Vos, subsp. nov.

F. divaricata subsp. *divaricata* affinis sed solum arenaria, foliis suberectis, perigonio brunneo vel fulvo differt.

Type: Cape, Vanrhynsdorp, De Lille, Nardouwspas, *Van Breda* sub *De Vos* 2295 (STE, holo.).

Leaves suberect, slightly glaucous. *Perianth* largely brown, purplish-brown, or yellowish-brown, without spots, with limbs shorter to slightly longer than the claws, with acuminate or attenuate tips; *nectaries* to 3 mm long, basal and sometimes 3-lobed on the outer claws and 1–3 mm above the bases of the inner claws. *Filaments* with the free upper portions 3(–4) mm long. *Seeds* dull, brown or golden brown, finely reticulate-foveolate.

Chromosome number: $2n = 20$.

Flowering period: October to November, rarely in September. The flowers remain open for one day only.

Distribution: Western coastal districts from southern Namaqualand to the Cape flats; in deep coastal sand.

CAPE—3017 (Hondeklipbaai): Road to Hondeklipbaai (–AD), *De Vos* 2402 (STE).

—3118 (Vanrhynsdorp): Ca. 16 km NO of Strandfontein (–CA), *De Vos* 2356

(STE); 1 ml NW of Vredendal (-CB), *Van der Merwe* 152 (STE); Between Klawer and Vanrhynsdorp (-DA-C), *Watermeyer* NBG 1951/30 (BOL); De Lille, Nardouwspas (-DD), *Van Breda* sub *De Vos* 2295 (STE).

—3217 (Vredenburg): N van Saldanhabaai (-DD), *De Vos* 76/15.

—3218 (Clanwilliam): Nortier proefplaas, Lamberts Bay (-AB), *Van Breda* sub *De Vos* 2341 (STE); Verlorevlei, N edge near Redelinghuis (-AD), *Pillans* 8123 (BOL); Sandy slopes between Verlorevlei and Rooikransberg, *Pillans* 8124 (BOL); Between Clanwilliam and Citrusdal (-BD), *De Vos* 2361 (STE); Eendekuil (-DB), *Strey* s.n. 2.10.46 (M).

—3318 (Cape Town): Langebaan (-AA), *L. Bolus* NBG 3184/32 sub *F. langebaanensis* L. Bol., ined. (BOL, K); Churchhaven, *Lewis* s.n. (BOL); On road to Gansekraal (-AD), *Barker* 730 (NBG); Silverstream Strand (-CB), *De Vos* 2339 (STE); University of Western Cape, Bellville (-DC), *Delpierre* sub *De Vos* 2385 (STE).

This subspecies is best distinguished by its erect habit, brown flowers, late flowering period and by its habitat in deep sand.

As indicated on certain specimens in the Bolus herbarium, L. Bolus intended to describe this as a distinct species, *F. langebaanensis*, but the name was not published.

c. subspecies **aurea** De Vos, subsp. nov.

Ferraria divaricata subsp. *arenosa* et subsp. *divaricata* affinis a qua differt floribus aureis fere concoloribus, limbis perigonii horizontaliter patentibus, solum in partibus superioribus recurvis, unguis aequantibus vel eis brevioribus.

Type: Cape, Clanwilliam, Langdam, *De Vos* 2297 (STE, holo.).

Leaves suberect, slight glaucous. *Flowers* with a sweetish scent, bright golden yellow (RHS 5A, 12A, 14A), the perianth segments with concolorous margins, the limbs with a diffuse greenish median zone or greenish dots above the claws, equal to or shorter than the claws, horizontally spreading and with only the upper one quarter recurved, tips acuminate or shortly attenuate; *nectaries* usually small, almost hidden near the bases of the claws. *Filaments* free for (2,5–)3–4 mm above the filament tube. *Seeds* almost globose with a rather dull, light brown, reticulate-foveolate testa.

Chromosome number: $2n = 20$.

Flowering period: September to end of October. The flowers remain open for one day only.

Distribution: From Namaqualand to Clanwilliam.

CAPE—3017 (Hondeklipbaai): Between Hondeklipbaai and Wallekraal (-AD), *Lewis* NBG 2052/32 (BOL).

—3118 (Vanrhynsdorp): Between Papendorp and Doringbaai (-CA), *De Vos* 2384

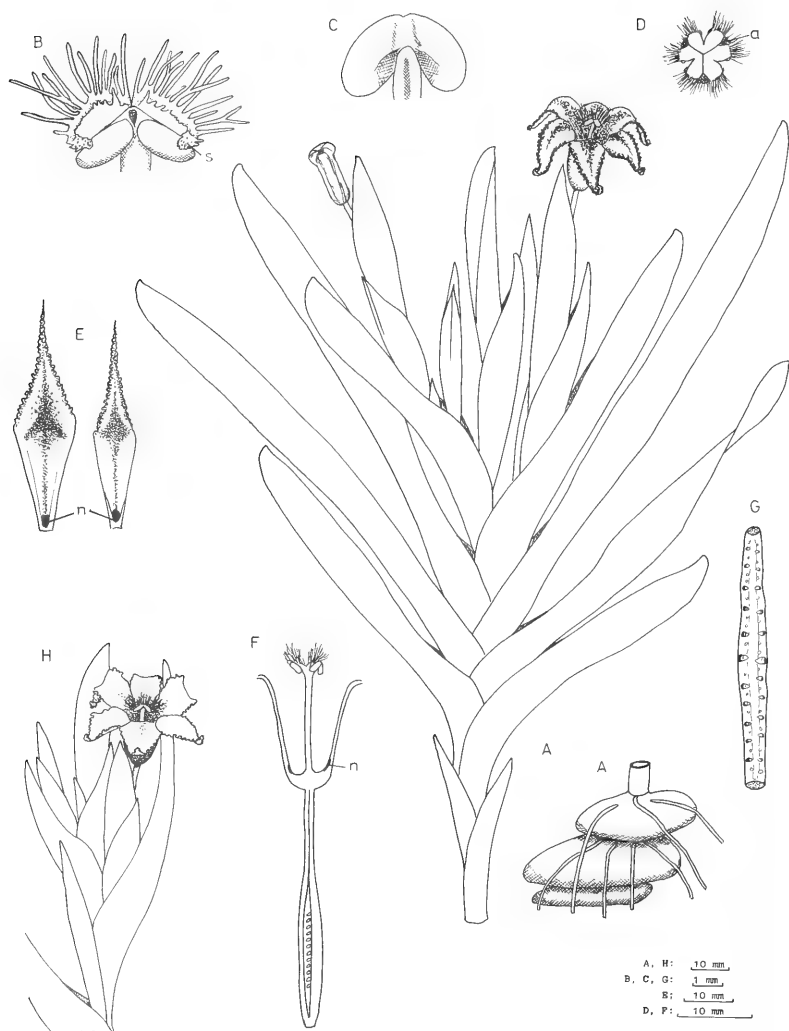


FIG. 23.

Ferraria divaricata, A-G subsp. *australis*. A, plant; B, one style branch and anther, side view; C, anther and free part of filament, adaxial side; D, style branches seen from above; E, outer (left) and inner (right) perianth segments; F, base of flower, longitudinal view; G, transverse section of leaf blade. H, subsp. *aurea*, flowering branch; a, anther; n, nectary; s, stigma.

(STE); Ca. 3 km NW of Klawer towards Vredendal (-DA), *De Vos* 2333 (STE). —3218 (Clanwilliam): Langdam, ca. 15 km E of Lamberts Bay (-AB), *De Vos* 2297 (STE).

In the living state this subspecies is readily distinguished by its bright yellow, almost concolorous flowers with short perianth limbs. In herbarium specimens the colour has usually faded and some of the older herbarium material without dissected flowers, which have now been placed under *F. divaricata* subsp. *divaricata* or subsp. *arenosa*, may perhaps be subspecies *aurea*; such is *Acocks* 16432 in PRE from 3118–BC, in which the flower colour is recorded as orange.

d. subspecies **australis** De Vos, subsp. nov.

Haec subspecies nova ab aliis subspeciebus *Ferrariae divaricatae* distinguitur numero chromosomatum polyploideo, segmentis exterioribus perianthii plerumque maculatis, partibus liberis superioribus filamentorum 1,5–2(–2,5) mm longis, seminibus nitidis cinnamomeis, irregulariter angulatis.

Type: Cape, Montagu, Whitehill Karoo Garden, *Compton* 17412 (NBG, holo.).

Leaves spreading or sometimes suberect. *Flowers* with a sharp unpleasant scent. *Perianth* greenish-yellow, orange-brown or purplish-brown, with olive-green, orange-brown or dark brown margins, the outer segments usually with a greenish-blue or brownish median zone and with small brown, purple or green spots above the claws; limbs longer than the claws, tapering to long slender attenuate tips; *nectaries* as in subsp. *divaricata*. *Filaments* with their free upper portions 1,5–2(–2,5) mm long. *Seeds* shiny golden brown, angled by pressure, the testa irregularly wrinkled.

Chromosome number: $2n = 40$.

Flowering period: August to October. The flowers remain open for two or sometimes three days.

Distribution: From Vanrhynsdorp southwards to the inland districts of Ceres, Worcester, Montagu and Oudtshoorn, and the south coast district of Bredasdorp (hence the epithet); in sandy shale or clayey ground.

CAPE—3118 (Vanrhynsdorp): Lutzville-Vredendal (-CB), *De Vos* 2373 (STE); Between Vanrhynsdorp and Vredendal (-DA), *De Vos* 2367 (STE). —3319 (Worcester): Cold Bokkeveld (-AB), *Alston* SAM 10784; Romansriver, Mostertshoek (-AC), *Mostert* sub *De Vos* 2290, 2314 (STE); Mitchell's Pass (-AD), *Guthrie* 3401 (SAM); Flats E of Prince Alfred's Hamlet, *Oliver* 5062 (STE, S); Rhodona, Ceres Karoo, *Cillié* sub *De Vos* 2334, 2335 (STE); Karoopoort (-BA), *Kirstenbosch Exped.* NBG 408/44; Ceres Karoo (-BB), *Marloth* 5296 (BOL, PRE); Osplaas sta. NE of De Doorns (-BC), *Mauve & Oliver* 125 (PRE, STE); Hex River Pass, *Leighton* 3173 (BOL); Between Karoopoort and

Ceres, *Dymond* BOL 21236; In convalle flum. Hex prope De Doorns, *H. Bolus* 13060 (BOL); Bainskloof E end (-CA), *Gillett* 1723 (STE); Veldreservaat, Worcester (-CB), *Olivier* 187 (STE, PRE); Worcester, *Van Breda* 49 (PRE); Sandy flats near Brandvlei, *Lewis* 6049 (NBG); Between Franschhoek and Villiersdorp (-CC-D), *Lewis* 2895 (SAM); Doorn River 12 mls from Villiersdorp (-CD), *De Villiers* s.n. 25.10.62 (NBG); Near Mowers station (-DA), *De Vos* 2299 (STE); Karookoppies SE of De Wet station, *Oliver* 5029 (STE); 8 mls from Robertson to McGregor (-DD), *Marsh* 974 (PRE, STE).

—3320 (Montagu): Tweedside (-AB), *Barker* 7463 (NBG), *Marloth* 10807 (PRE); Whitehill Karoo Garden (-BA), *Compton* 7631, 5590, 13931, 14857, 17412 (NBG); 3 mls N of Matjiesfontein, *Acocks* 17163 (PRE); Matjiesfontein-Laingsburg (-BA-B), *Moffett* 713 (STE); Near Ashton (-CC), *Barker* 1978 (NBG); Bonnievale, *Dymond* NBG 1940/33 (BOL, PRE, K).

—3321 (Ladismith): Naby Muiskraal, N van Garciaspas (-CC), *Moffett* sub *De Vos* 2403 (STE).

—3322 (Oudtshoorn): Meiringspoort (-BC), *Goldblatt* sub *De Vos* 2337 (STE); 9 mls W of Oudtshoorn towards Calitzdorp (-CA), *Zinn* SAM 65672.

—3419 (Caledon): E of Kleinmond (-AC), *Vlok* sub *De Vos* 2380 (STE).

—3420 (Bredasdorp): Stormsvlei kloof (-AA), *Lewis* 1603 (SAM); Korlandskloof W of Stormsvlei, *Oliver* 6025 (STE); Bontebokpark (-AB), *Marais* s.n. (STE); 20 mls W of Swellendam, *Goldblatt* 453 (BOL); Aerodrome near Bredasdorp (-CA), *Keast* s.n. 18.9.51 (NBG).

Herbarium specimens of this subspecies can best be distinguished by their localities, by filaments with the free portions very short, and shiny seeds angled by pressure.

The specimen *H. Bolus* 9982 in BOL, (in salo argillaceo in apertis prope Moorreesburg) is probably this subspecies. If this is so, this locality (Cape Town 3318, BA/B) is the nearest that this subspecies has spread to the Cape Peninsula.

Evidence of hybridization between this subspecies and *F. crispa* has been found in, firstly a specimen collected by *Oliver* sub *De Vos* 2407 on the top of Hex River Pass near Touwsrivier (3318-BD) which is a pentaploid ($2n = 50$). This has a brown perianth with a bluish-purple median zone and small dark spots on each limb; the ovary has only a short rostrum, but the anthers and stigmas resemble *F. divaricata*. Secondly, on the farm Kleiheuvel, Bredasdorp district (3420-CA), plants occur (*De Vos* 2405, 2381) with characters intermediate between the present subspecies and *F. crispa*, the perianth resembling that of the latter species and the anthers and stigmas that of *F. divaricata*. These plants are, however, hexaploids with $2n = ca. 60$. How they originated, is impossible to say.

8. *Ferraria kamiesbergensis* De Vos, spec. nov.

Caluis 50–200(–500) mm longus, plerumque vaginis foliorum obtectus. *Folia* 100–250(–500) mm longa, 5–12 mm lata, apicibus plerumque minute cuculatis

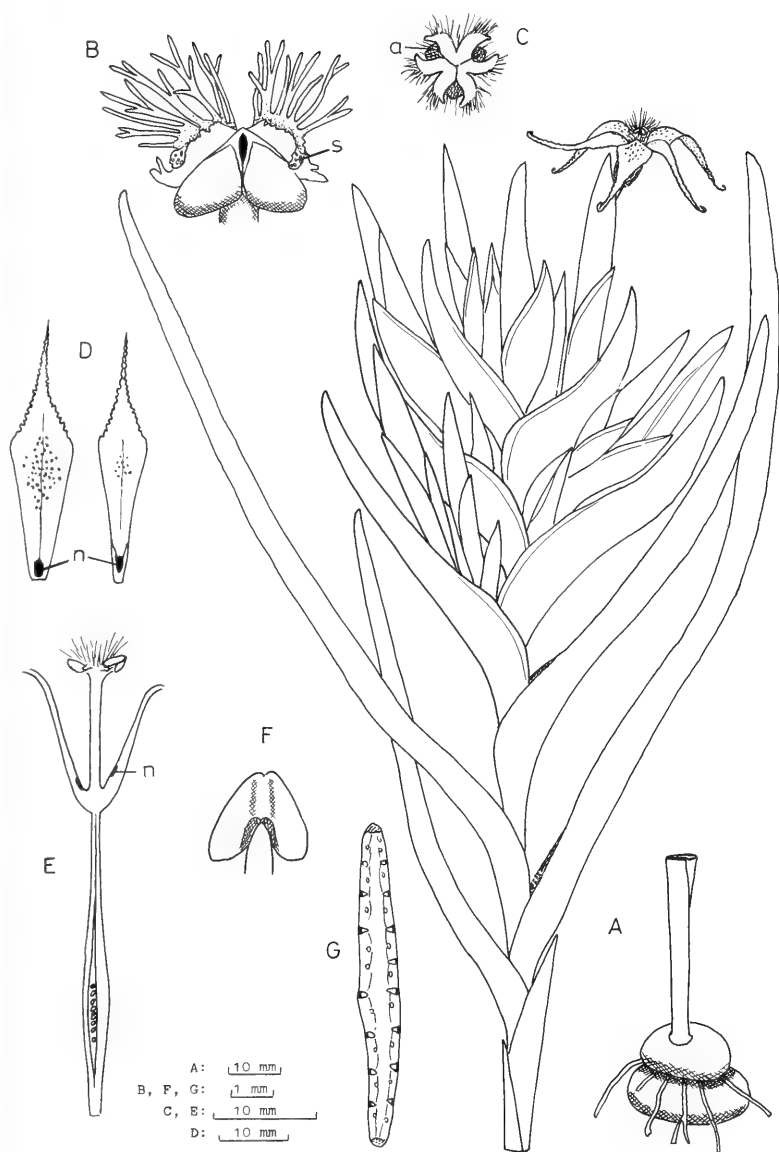


FIG. 24.

Ferraria kamiesbergensis. A, plant; B, one style branch and anther, side view; C, style branches and anthers, top view; D, outer (left) and inner (right) perianth segments; E, base of flower, longitudinal view; F, anther and free part of filament, adaxial side; G, transverse section of leaf blade; a, anther; n, nectary; s, stigma.

vel incurvatis vel acutis. *Cymae* paucae vel plurimae. *Spathae* marginibus membranaceis angustis, spatha exterior (25–)30–45 mm longa, interior 50–65 mm longa. *Flores* 45–60 mm longi, leviter odorati, cremei vel flavidi vel e cinereo virides, viridi- vel cinereo-punctulati. *Perigonium* unguibus imbricatis, cupulam anguste infundibularem 8–12 mm longam facientibus, nectariis minutis, bases unguium positis; *segmenta* apicibus longis tenuibus attenuatis, *segmenta* exteriora 6–9 mm lata, interiora 4–7 mm lata. *Tubus filamentorum* 8–10(–12) mm longus, partibus liberis, 1.5–2 mm longis; *antherae* horizontales, thecae divaricatae. *Ovarium* 18–30 mm longum, rostro gracile praeditum; *stylus* 8–12 mm longus, ramis e basi dilatatis, complanatis, bifidis, fimbriis ad 3 mm longis; *stigmata* ut in *F. uncinata*. *Capsula* ellipsoidea, ca. 30 mm longa, rostrata. Chromosomatum numerus $2n = 20$.

Type: Cape, Kamiesberg, Rondefontein, Oliver 5970 (STE, holo.).

Plants, 100–300(–500) mm tall. *Corm* ca. 15–30 mm diam., irregular and oblique or almost discoidal. *Stem* 50–200(–500) mm long, covered or rarely partly covered by leaf sheaths. *Cataphylls* 1–2. *Foliage leaves* several, 100–250(–500) mm long, 5–12 mm wide, tip minutely hooked, incurved or acute. *Cymes* few to numerous. *Spathes* with narrow pale membranous margins, outer spathe (25–)30–45 mm long, inner 50–65 mm. *Flowers* 45–60 mm long, faintly and pleasantly scented, cream to pale yellow or pale greyish-green, often with minute dark green or grey spots above the claws, and with darker yellow or brownish-green, slightly crisped tepal margins. *Perianth* with overlapping claws forming a narrowly funnel-shaped cup 8–12 mm deep and 6–10 mm diam. at the rim; *nectaries* minute, basal on the outer claws and almost basal in a groove on the inner claws; *segments* with long, slender, attenuate tips, outer segments $25\text{--}32 \times 6\text{--}9$ mm, inner $22\text{--}30 \times 4\text{--}7$ mm. *Filament tube* 8–10(–12) mm long, pale, the free upper portions 1.5–2 mm long; *anthers* horizontal, at first 3.5 mm long, later less than 2 mm, with widely divaricate lobes, dark purple or pale; pollen orange or yellow. *Ovary* 18–30 mm long, with a rostrum 8–18 mm long; *style* 8–12 mm long, the branches flat, 3–4 mm wide, bifid, with fimbriae to 3 mm long, pale towards the tips; *stigmas* as in *F. uncinata*. *Capsule* ellipsoid, ca. 30 mm long, rostrate.

Chromosome number: $2n = 20$.

Flowering period: End of August to October. A flower remains open for one to two days.

Distribution: Sparsely distributed in Namaqualand south of Springbok, on Kamiesberge, and in the western Karoo; in sand or sandy ground.

CAPE—2917 (Springbok): Flats S of Populiersberg S of Springbok (-DB), Thompson 1301 (STE).

—3017 (Hondeklipbaai): Wallekraal (-BC), Compton 5405 pro parte (BOL,

possibly not in NBG); 38 km from Garies to Wallekraal, *Dryfhout* sub *De Vos* 2399 (STE).

—3018 (Kamiesberg): De Kom, 3 mls from Leliefontein (-AB), *Leipoldt* 3563 (BOL); Wilgenhout Ravine (-AC), *P. Sladen Mem. Exp.* 6812 (BOL); Southern Kamiesberg, Rondefontein S of Nartjiesdam (-CA), *Oliver* 5970 (STE).

—3019 (Loeriesfontein): Onderste Camdini on road between Kliprand and Loeriesfontein (-CC), *Thompson* 2882 (STE).

—3119 (Calvinia): Near Hantamsriver 30 mls NW of Calvinia on Loeriesfontein road (-AB), *Lewis* SAM 61921 (BOL), 2534 (SAM); Loeriesfontein road 32 mls from Calvinia, *Johnson* 603 (NBG); 29 km from Loeriesfontein towards Calvinia, *De Vos* 2347 (STE); 17 mls along Klipwerf road from Calvinia-Williston road (-BB), *Hiemstra* 622 (NBG).

This species is distinguished by a pale yellow or sometimes pale greyish-green flower resembling that of *F. uncinata* subspecies *macrochlamys* and *F. brevifolia*, with its long, narrow, attenuate perianth segments, small divaricate anthers and rostrate ovary; and further by long linear leaf blades with smooth margins. It is intermediate between *F. uncinata* and *F. divaricata*, differing from the former in its smooth leaf margins and flowers usually with a slightly shallower perianth cup. It differs from *F. divaricata* in its smaller, pale flowers with narrower perianth cup and segments, and minute nectaries.

The specific epithet has been chosen as this is one of the few species of *Ferraria* found on the Kamiesberge.

9. *Ferraria uncinata* Sweet, Flow. gdn. ser. 1, sub t.161 (1826). *Iconotype*: l.c. t.161.

Plants 100–250(–400) mm tall. *Corm* almost symmetrical, somewhat discoidal or with the top surface almost flat, to 35 mm diam. and 15 mm high. *Stem* 50–150(–300) mm long, covered with leaf sheaths. *Cataphylls* 1–2, pale. *Foliage leaves* several, suberect or spreading, often somewhat falcate, 80–200 × (3–)5–10(–18) mm, with finely crisped or irregularly toothed margins, obtuse or with hooked incurved tip, with sheaths as wide as, or slightly wider than the leaf blades. *Cymes* several. *Spathes* with narrow, pale, membranous margins and incurved tips, outer spathe (25–)30–40(–50) mm long, inner (35–)50–60 mm. *Flowers* (30–)45–60 mm long, faintly and pleasantly scented, pale yellow, blue or purplish-blue with narrow or wide, greenish or yellowish segment margins. *Perianth* with overlapping claws forming a narrowly funnel-shaped cup 10–12 (–14) mm deep, 6–9 mm diam. at the rim; *nectaries* minute, basal, or sometimes subbasal on the inner claws; *segments* with long, slender, attenuate tips and finely crisped, often discolourous margins, outer segments 30–40 mm × 6–10 mm, sometimes sparsely dotted above the claws, inner 25–35 mm × 4–7(–9) mm. *Filament tube* 8–12 mm long with the free upper portions less than 2 mm long; *anthers* horizontal, at first 3 mm long, later less than 2 mm, with widely divaricate

lobes and yellow or orange pollen. *Ovary* (15-)20-25(-40) mm long with a rostrum (5-)8-15(-20) mm long; *style* 10-15 mm long, branches flattened, 3-4 mm wide, bifid, with fimbriae 2-4 long; *stigmas* ca. 1 mm, grooved, curved towards the anther lobes. *Capsule* ellipsoid, ca. 20-25 mm long, rostrate; *seeds* ca. 3 mm diam. with shiny brown testa.

Chromosome number: $2n = 20$.

Flowering period: August to October, rarely to November. A flower remains open for two to three days.

Distribution: From Springbok to Garies and from Clanwilliam to Malmesbury, in sandy shale or somewhat clayey ground.

This species is readily distinguished by its leaves, most, or some of which have finely crisped, irregularly toothed, or somewhat wavy margins. It stands nearest *F. kamiesbergensis*, its flower resembling that of this species in shape and sometimes in colour, and in its small anthers with widely divaricate lobes, its rostrate ovary and flattened style branches.

It differs from *F. divaricata* in its crisped leaf margins, its smaller, differently coloured perianth with a narrower funnel-shaped cup and narrower segments, and in its smaller anthers. A collection, *Compton 13896* from the Mamre hills, Malmesbury, has foliage leaves showing a slight crispulation and flowers resembling those of *F. divaricata*; it may represent a hybrid between the two species.

Two subspecies, previously considered to be distinct species, are recognised. They differ only in flower colouring and geographic distribution, being separated by the Knersvlakte of Vanrhynsdorp where no *Ferraria* species has been found to occur.

The iconotype, Sweet t.161, does not show crisped leaf margins. The flower depicted is, however, so typical, that there can be no doubt what species is figured as *F. uncinata*. (Crispulation sometimes occurs in this species on only a few of the leaves and could therefore have been overlooked.)

KEY TO THE SUBSPECIES

- Perianth segments blue with narrow yellowish-green margins, or with a purplish-blue median zone and wide yellowish margins; south of Vanrhynsdorpa. subsp. **uncinata**
 Perianth segments pale yellow, often with slightly darker yellow margins; north of Vanrhynsdorpb. subsp. **macrochlamys**

a. subspecies **uncinata**

Ferraria uncinata Sweet, Brit. Flow. gdn. ser. 1 t.161 (1826), *iconotype*; Klatt, in Dur. & Schinz, Consp. Fl. Afr. 5: 156 (1895).

F. framesii L. Bol., in J. Bot. Lond. 71: 123 (1933). *Type*: Cape, Clanwilliam, hill about 6 mls south of Clanwilliam, *Ross Frames* BOL 19928 (BOL, holo.; SAM, iso.).

F. ferrariola sensu Eckl., Top. Verz.: 18 (1827), non (Jacq.) Willd. (1800), nec. Roemer & Schultes (1817), nec. Klatt (1895).

Icones: Sweet l.c.; Rice & Compton 1950 Pl. 187 f. 3 sub *F. antherosa*; Mason 1972 Pl. 25 f. 1; this work Figs 25 A–G, 13B.

Leaves suberect or spreading, 80–200 mm × 8–15(–18) mm, some (or rarely all) with irregular, finely toothed or crisped margins. *Perianth segments* bright to dark blue (RHS 90A, 93B, 103A, B), with narrow, green or greenish-yellow margins, or with a purplish-blue median zone and wide yellowish margins, the outer segments sometimes with purplish-blue dots above the claws.

Distribution: Mostly below the first escarpment from Clanwilliam to Malmesbury.

CAPE—3118 (Vanrhynsdorp): Gifberg (-DC), *Leipoldt* 4081 (BOL); Nardouw kloof (-DD), *Stokoe* SAM 59836.

—3218 (Clanwilliam): Zwischen Langevalei u. Heerenlogement (-AB), *Drège* s.n. Juli (S, partly); Elands Bay (-AD), *Leighton* 192 (BOL); Ramskop (-BB), *Leipoldt* 1049 (BOL), *De Vos* 2363 (STE); Clanwilliam, *Schlechter* 8413 (PRE, partly in BM, K, S); 2 mls S of Clanwilliam, roadside, *Marsh* 766 (STE); Next to Olifants River 5 km from Clanwilliam to Klawer, *Mauve & Oliver* 104 (PRE, STE); Prope Olifants River, Clanwilliam, *Pappe* SAM 70648; Olifants River valley near Nardouw road, *Lewis* 1349 (SAM); Nardouw road turn-off, *Lewis* 5213 (NBG); The Weir, Olifants River valley, *Lewis* s.n. 5 Sept. 1932 (BOL); Eastern banks of lower Clanwilliam dam, *Hugo* 443 (STE); Near dam, *Lewis* 1868 (SAM), *Van Breda* 4285 (STE); Hill about 6 mls S of Clanwilliam (-BD), *Ross-Frames* BOL 19928 (BOL, SAM); 15 mls N of Citrusdal, *Hall* 546 (NBG); Roadside Clanwilliam-Citrusdal, *De Vos* 2359 (STE); ½ km from N11 towards Algeria, *De Vos* 2377, 2398 (STE); Ca. 8 km N of Citrusdal, *De Vos* 2362 (STE); Aurora (-CB), *Loubser* 2180 (BOL); Berg Valley (-DA), *Lewis* 1867 (SAM); Het Kruis, *Thorne* SAM 52922, *P. Sladen* Mem. Exp. 8616 (K), *Compton* 15026 (NBG); Boskloof, Clanwilliam-Piketberg, *Compton* 9528 (NBG); 4 mls S of Piketberg (-DC), *Lewis* BOL 22259; Near The Rest (-DB), *Bolus* s.n. (BOL); Bergrivier bridge near Piketberg (-DC), *De Vos* 2325 (STE); Piketberg mountain, *Gentry* e.a. 18628 (PRE).

—3219 (Wuppertal): Brandewynsrivier E of Pakhuis Pass (-AA), *Lewis* 2297 SAM 60865 (PRE), BOL 22258, *Barker* 6572 (NBG); Near Porterville in the pass (-CC), *Leipoldt* 3842 (BOL).

—3318 (Cape Town): Hopefield (-AB), *Marloth* 8905 (PRE); 8 mls S of Hopefield, *Salter* 3900 (BOL); Darling Flora Reserve (-AD), *Lewis* 5075, 5745 (NBG), *Barker* 8658 (NBG); Moorreesburg (-BA), *Marloth* 11487 (PRE); Twenty-four Rivers, Porterville (-BB), *Immelman* NBG 1995/28 (BOL); Twenty-four Streams near Saron, *Lewis* BOL 31216; Prope Grūnekloof (-CB), *Ecklon* UJ305 (K, M, S); Kalbaskraal (-DA), *Strey* s.n. 5.10.46 (M).

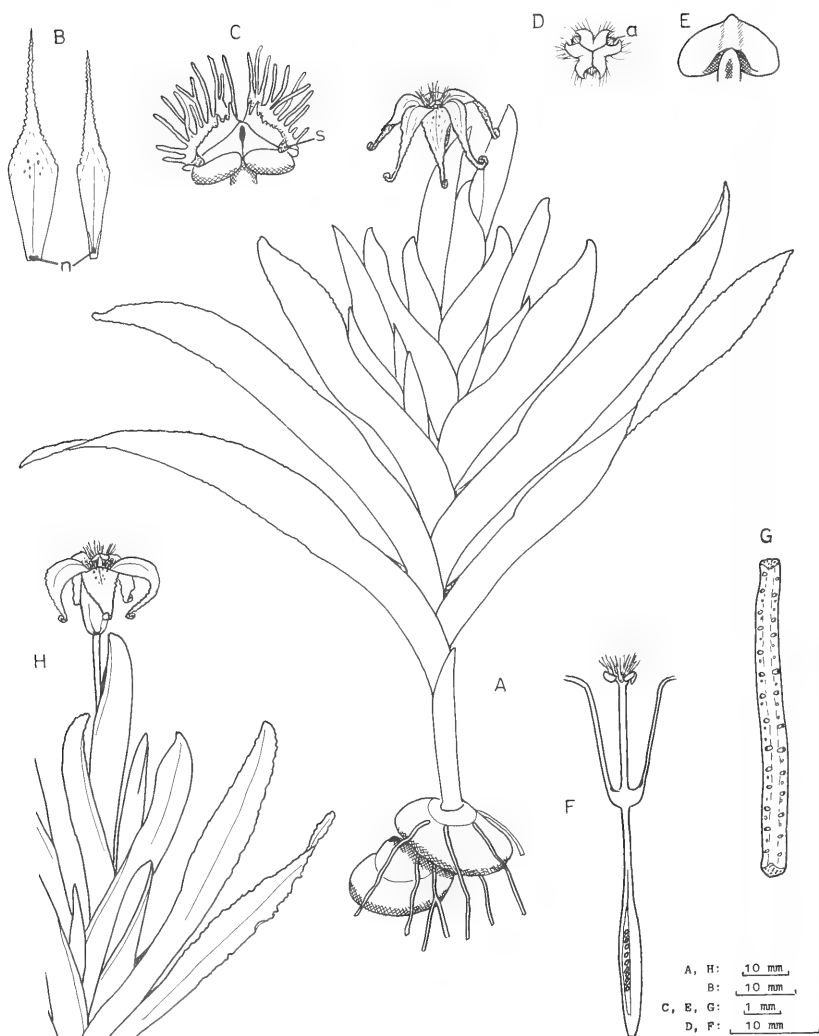


FIG. 25.

Ferraria uncinata, A-G subsp. *uncinata*. A, plant; B, outer (left) and inner (right) perianth segments; C, one style branch and anther, lateral view; D, style branches, top view; E, anther and free part of filament, adaxial side; F, base of flower, longitudinal view; G, transverse section of leaf blade. H, subsp. *macrochlamys*, part of plant; a, anther; n, nectary; s, stigma.

—3319 (Worcester): De Hoek estate near Saron (-AA), *Compton* NBG 1859/36, *Lewis* NBG 1859/36 (BOL); Saron, *Strey* s.n. 29.9.46 (M); Mostertshoek, Romansrivier (-AC), *De Vos* 2338 (STE).

Two collections from 3218-BB differ from the typical in flower colouring: those of *Mauve & Oliver* 104 in PRE and STE have yellow flowers with a narrow purplish median zone, and that of *Hugo* 443 in STE has flowers "brownish gold spotted green".

b. subspecies **macrochlamys** (Bak.) De Vos, comb. et stat. nov.

Lapeirousia macrochlamys Bak., in J. Bot. Lond. N.S. 5: 338 (1876) (basonym). Type: Cape, without precise locality, *Hb. Forsyth* s.n. (K, holo.); Bak., in J. Linn. Soc. Bot. 16: 155 (1877), & in Fl. Cap. 6: 31 (1896) pro syn.

Ferraria crispulata L. Bol., in J. Bot. Lond. 69: 260 (1931). Type: Cape, Hondeklipbaai, Bowesdorp, *Bolus* 19162 (BOL, holo.; BM, K, iso.).

Lower leaves spreading, often somewhat falcate, to 150 mm long, \times 3–10 mm, generally with strong, crisped or wavy margins. *Perianth segments* pale yellow (RHS 1D–9D), often with slightly darker yellow margins, outer segments with some bluish-green spots or a pale green median zone above the claws.

Distribution: Namaqualand, from Springbok to Garies, over a distance of about 120 km.

CAPE—2917 (Springbok): 1 ml W of Springbok (-DB), *Barker* 6701 (NBG); Near Springbok, *Lewis* 742 (SAM); 1 Meile südlich von Springbok, *Merxmüller & Giess* 3804 (M); 40 km SW of Springbok (-DC), *Goldblatt* 2877 (STE); Between Springbok and Kamieskroon (-DD), *Salter* 1444 (BM); Mesklip, *Lewis* 1035 (SAM); Near Darter's grave, *Lewis* 1376 (SAM).

—3017 (Hondeklipbaai): Grootvallei 20 km from Kamieskroon to Hondeklipbaai (-BB), *Thompson* 446 (STE); Skilpad, *Barker* 6820 (NBG); Grootvlei, *Lewis* 1375 (SAM), *Barker* 3746 (NBG); Bowesdorp, *Stokoe* SAM 25653, *Bolus* 19162 (BOL, BM, K), *De Vos* 2328 (STE); Kamieskroon, *Lewis* 5475 (NBG), *Thorne* SAM 48859; Brakdam (-BD), *Maguire* 963 (NBG); Twee Rivieren, Kamiesberg, *Pearson* 6822 (K); Garies hills (-DB), *Compton* 17179 (NBG), *Barker* 7406 (NBG); 6 mls N of Garies, *Leighton* 1369 (BOL).

Without locality: *Hb. Forsyth* s.n. (K).

This subspecies has flowers resembling that of *F. kamiesbergensis* and differs from the latter mainly in its strong, crisped or wavy leaf margins.

10. ***Ferraria brevifolia*** G. J. Lewis, in Ann. S. Afr. Mus. 40: 119 (1954).

Type: Cape, Vanrhynsdorp, 2 mls south of Nuwerus, *Lewis* 1374 SAM 57943 (SAM, holo.).

F. namaquensis Schlechter ined.

Icones: *Lewis* l.c.; this work Figs 26, 13B.

Plants 70–200 mm tall. *Corms* depressed globose or irregular, 10–30 mm diam., often in an irregular, almost horizontal row. *Stem* 60–150 mm long, covered with leaf sheaths. *Cataphylls* 2–3, sometimes reddish at their tips. *Foliage leaves* numerous, distichous, 50–100(–150) mm long, the lower ones spreading, leaf sheath longer and narrower than the obliquely ovate blade which is 7–15(–20) × 6–12 mm and has thickened margins and a slightly incurved, acute to obtuse tip. *Cymes* few. *Spathes* with incurved tips, outer spathe (35–)40–45 mm long, with somewhat reddish membranous margins, inner (45–)50–65 mm long, with pale margins. *Flowers* 30–60 mm long, sweetly scented, pale yellow (RHS 10A) or greenish-yellow. *Perianth* with overlapping claws forming a narrowly funnel-shaped cup 10–12 mm deep, 10–14 mm diam. at the rim; *nectaries* minute, pale green, basal on the claws, sometimes bilobed on the inner claws; *segments* with very long, slender, attenuate tip and orangy or fawn-yellow, slightly crisped margins; outer segments 33–40 × 8–10 mm, with a few green spots above the claws, inner slightly shorter, 4–6 mm wide, the claws very narrow. *Filament tube* 8–10 mm long, the upper free portions scarcely 1 mm long; *anthers* horizontal, with divaricate lobes, at first 3 mm long, later 1.5–2 mm × 2 mm, pollen pale yellow to orange-yellow. *Ovary* 20–30 mm long, with a rostrum ca. 8–12 mm long; *style* 8–12 mm long, the branches widened to 3 mm, shallowly bifid, with dense tufts of pale green fimbriae ca. 3 mm long; *stigmas* 1.5 mm long, grooved, sharply curved towards the anther lobes. *Capsule* 15–25 mm long, rostrate; *seeds* 3 mm diam., brown, shiny.

Chromosome number: $2n = 20$.

Flowering period: August to September. A flower remains open for two days.

Distribution: Southern Namaqualand, over a distance of about 80 km, from Garies to Nuwerus, in stony, sandy ground.

CAPE—3018 (Kamiesberg): Between Bitterfontein and Garies (–CA–C), *Lewis* NBG 2065/32 (BOL).

—3118 (Vanrhynsdorp): Nuwerus, stony veld (–AB), *Hall* 4114 (NBG, PRE), *Barker* 3734 (NBG); 2 mls S of Nuwerus, *Lewis* 1374 (SAM 57943), *De Vos* 2326 (STE); Bitterfontein, *Schlechter* 11031 (BOL, B, BM, BR, K, PRE, S, Z) sub *F. namaquensis* Schlechter, ined.

This is a very distinct species distinguished by its numerous, distichous, spreading leaves with a very short, obliquely ovate blade possessing conspicuously thickened, smooth margins, and by its pale yellow flowers resembling those of *F. kamiesbergensis* and *F. uncinata* subsp. *macrochlamys*. The filaments are not completely united as indicated by Lewis; they have very short free tips scarcely one millimetre in length.

EXCLUDED AFRICAN SPECIES

F. atrata Lodd., Bot. Cab. 14 t.1356 (1828). The description, as well as the figure (iconotype) is inadequate and the species cannot be identified.

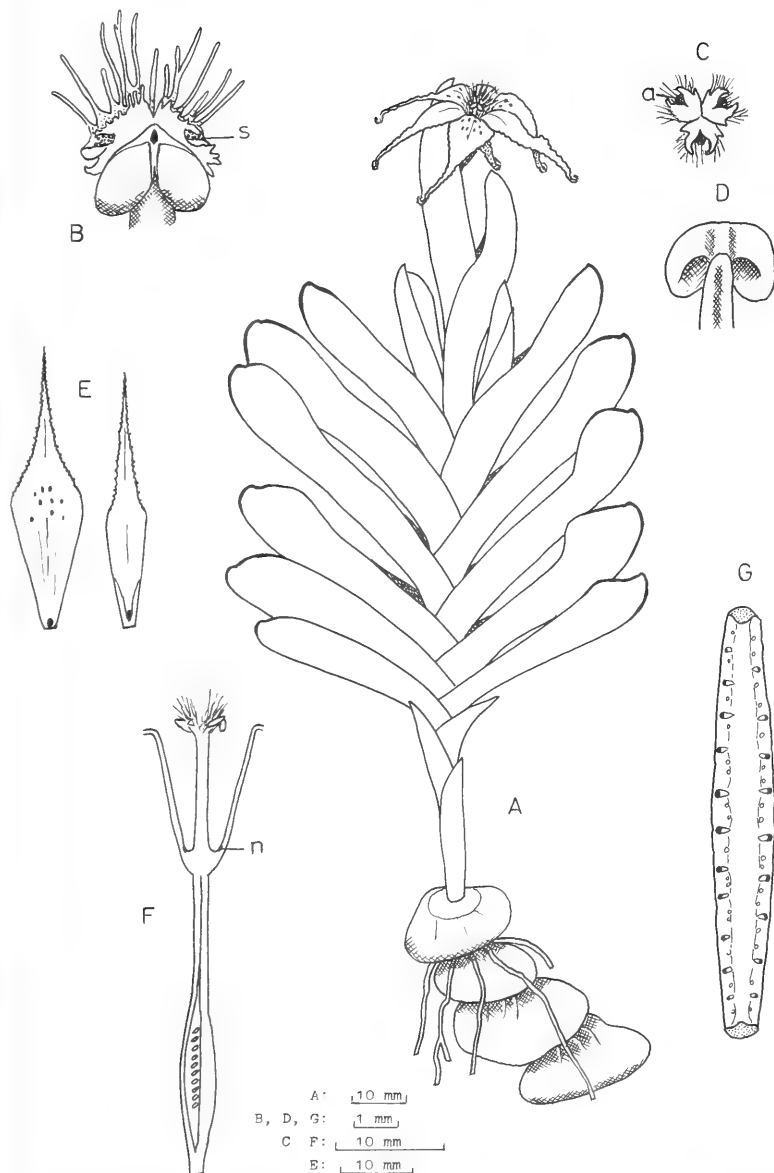


FIG. 26.

Ferraria brevifolia. A, plant; B, one style branch and anther, lateral view; C, style branches, top view; D, anther and free part of filament, adaxial side; E, outer (left) and inner (right) perianth segment; F, base of flower, longitudinal view; G, transverse section of short leaf blade; a, anther; n, nectary; s, stigma.

F. blanda Salisb., Prodr. Stirp.: 42 (1796). Salisbury named as synonym *Moraea indoides* L. which is an orthographic error for *M. iridoides* L. The latter is the type species of *Dietes* (Goldblatt 1976c: 695).

F. fimbriata Burm., Nova Acta Acad. Caes. Leop. Car. 2: 201 (1761). The description and figure (iconotype) are inadequate for identifying this species. Miller (1759b, 1768) misidentified it as *F. undulata*.

F. lugubris Salisb., Prodr. Stirp.: 42 (1796) is *Moraea lugubris* (Salisb.) Goldblatt (Goldblatt 1976c: 706).

F. ocellaris Salisb., l.c. p. 41 is *Moraea aristata* (Delar.) Aschers. & Graebn. (Goldblatt 1976c: 773).

F. tricuspis Willd., Enum. Hort. Berol.: 691 (1809) is, according to the *Index Kewensis*, *Vieusseuxia aristata* and *V. glaucopsis*, both so-called "peacock" moraeas, which are now *M. aristata* (Delar.) Aschers. & Graebn. and *M. villosa* (Ker) Ker (Goldblatt 1976c: 773, 775).

F. tristis Salisb., Prodr. Stirp.: 42 (1796) is *Moraea vegeta* L. (Goldblatt 1976c: 693).

EXCLUDED EXTRA-AFRICAN SPECIES

According to the *Index Kewensis* e.a. the following belong to different genera:

F. cathartica Mart., Reise Bras. 1: 548 is *Trimezia juncifolia* B. & H.f.

F. crocea Salisb., Prodr. Stirp.: 41 (1796) is *Belamcanda punctata* Moench.

F. elegans Salisb., l.c. p. 42 is *Marica northiana* Ker.

F. elongata R. Grah., in Edinb. N. Phil. J. 1830: 173. This is probably *Gelasine azurea* Herb., in Curtis's bot. Mag. t.3779 (1840), according to B. L. Burtt (private communication). The epithet *elongata*, however, antedates *azurea*.

F. ixioides Willd., Sp. Pl. 3: 582 (1800) is *Libertia ixioides* Spreng.

F. lahue Molina, Sagg. Stor. Nat. Chile ed. 2 p. 110 (1810) is *Herbertia lahue* (Molina) Goldblatt, in Ann. Mo. Bot. Gdn. 64: 379 (1976).

F. lurida Salisb., Prodr. Stirp.: 41 (1796) is *Trimezia lurida* Salisb. (1812).

F. ochroleuca Salisb., l.c. p. 42 is *Sisyrinchium striatum* Smith.

F. parviflora Salisb., l.c. p. 43 is *Eleutherine plicata* Herb.

F. pavonia L.f., Suppl. p. 407 (1781) is *Trigridia pavonia* (L.f.) DC.

F. plana Larranaga, Escritos D. A. Larranaga 2: 212, in Publ. Inst. Hist. Geog. Urug. (1923). According to Dr H. S. Osario, Museo de Historia Natural, Montevideo, Larranaga's herbarium was lost in the past century. Judging from the description, this is not a *Ferraria* species.

F. plicata Larranaga l.c. See note under *F. plana*.

F. pulchella Salisb., Stirp.: 42 (1796) Prodr. is *Sisyrinchium angustifolium* Miller.

F. purgans Mart., Reise Braz. 1: 547 is *Trimezia juncifolia* B. & H.f.

F. pusilla Link & Otto, Ic. Pl. Select. 125 t.59 (1820-28) is *Cypella pusilla* B. & H.f.

F. tigridia Sims, in Curtis's bot. Mag. 15 t.532 (1801) is *Tigridia pavonia* (L.f.) DC.

F. violacea Salisb., Prodr. Stirp.: 42 (1796) is *Sisyrinchium bermudiana* L.

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NOTES ON THE NOMENCLATURE OF *PELARGONIUM* (GERANIACEAE)

J. J. A. VAN DER WALT

(Department of Botany, University of Stellenbosch)

ABSTRACT

The first legitimate publication of the name *Pelargonium* appeared in Aiton's *Hortus Kewensis* of 1789. This generic description was however copied from L'Héritier's unpublished manuscript titled *Compendium Generalogium*, for which reason L'Héritier is considered to be the author of *Pelargonium*. The specific descriptions of *Pelargonium* in the *Hortus Kewensis* were supplied by L'Héritier and were taken verbatim from his *Compendium Generalogium*. For this reason L'Héritier should also be regarded as the author of these species. *Pelargonium cucullatum* (L.) L'Hérit. (*Geranium cucullatum* L.) is proposed as lectotype species of the genus.

UITTREKSEL

AANTEKENINGE OOR DIE NOMENKLATUUR VAN *PELARGONIUM* (GERANIACEAE)

Die eerste wettige publikasie van die naam *Pelargonium* het verskyn in Aiton se *Hortus Kewensis* van 1789. Hierdie genusbeskrywing is egter oorgeneem uit die ongepubliseerde manuskrip van L'Héritier met die titel *Compendium Generalogium*, en om hierdie rede word L'Héritier as outeur van *Pelargonium* aangewys. Die spesiebeskrywings van *Pelargonium* in die *Hortus Kewensis* is voorsien deur L'Héritier en is woordeliks oorgeneem uit sy *Compendium Generalogium*, en daarom moet L'Héritier as die outeur van hierdie spesies beskou word. *Pelargonium cucullatum* (L.) L'Hérit. (*Geranium cucullatum* L.) word voorgestel as lektotipe-spesie van die genus.

HISTORICAL REVIEW

The name *Pelargonium* was derived from the Greek word "Pelargos" meaning stork—it refers to the elongated schizocarp which resembles the bill of a stork in appearance.

Burman (1738) was the first to use the name *Pelargonium*. In his *Rariorum Africanarum Plantarum* eight species of *Pelargonium* were described and illustrated by Hendrik Claudius. It is not possible to identify all the species in this work, but the current *P. cucullatum* (L.) L'Hérit. is doubtlessly one of the species. Burman gave phrase names to the eight species.

Linnaeus (1753) and several successive botanists recognised only a single genus, *Geranium*, until the French botanist Charles-Louis L'Héritier de Brutelle distinguished *Pelargonium* as a genus separate from *Geranium*.

L'Héritier was by vocation a magistrate in Paris, but he was also a noted amateur botanist. It is known that he was continually in contact with European and

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British botanists. He was in active correspondence with Sir Joseph Banks in connections with various matters, including the Geraniaceae (Dawson, 1958), and in 1786 he visited London to work in Banks' herbarium and to consult Dryander. At this stage he made it known to Dryander "That he desired to write a monograph on the genus *Geranium*" (Dawson, 1958). L'Héritier started to work on this monograph, but apparently it was never completed. His unfinished manuscript *Compendium Generalogium exhibens Erodium, Pelargonium, Geranium, Monsoniam et Grielum*, dated 1789, remained unpublished and after his death it was acquired by A. P. de Candolle. Printed but unpublished proof sheets (64 pages) of this work are at present at the Conservatoire Botanique, Geneva. In these proofs 31 species of *Erodium* and 89 species of *Pelargonium* were described. (Actually the descriptions of only 85 species of *Pelargonium* are extant, as pages 57 and 58 containing the description of four species, have been lost.) Also in the Conservatoire Botanique is a manuscript introduction to the monograph in L'Héritier's own handwriting. In this introduction he provides, amongst others, an explanation of the respective genera of the Geraniaceae. The fact that this work was never published, can probably be ascribed to the contemporary situation in France. It was a time of political unrest during the French Revolution, in which L'Héritier was intimately involved due to his vocation as magistrate. He was murdered on 16 August 1800 in Paris (Stafleu, 1963).

However, a work of L'Héritier which was published, is his *Geraniologia seu Erodii, Pelargonii, Geranii, Monsoniae et Grieli Historia Iconibus Illustrata*. Although dated 1787–1788 on the title page, it was apparently only published in 1792 (Stafleu, 1967). It consists of 44 uncoloured engravings of which the majority were prepared from original drawings by P. J. Redouté; 31 of the plates depict pelargoniums.

AUTHORITY FOR THE GENUS *PELARGONIUM*

It is essential that the question of who should be regarded as the author of the genus *Pelargonium*, must be resolved. The first post-linnaean published work in which *Pelargonium* is recognised as a separate genus, is William Aiton's *Hortus Kewensis* (1789). During a recent visit to the British Museum (Natural History) I had the opportunity to examine a manuscript of the Geraniaceae for Aiton's *Hortus Kewensis*. In this manuscript, of which the major part was written by Solander although the handwriting of Dryander is also present, the name *Pelargonium* is nowhere used. Most probably it was Dryander who finally wrote up the Geraniaceae for the *Hortus Kewensis* (1789), as Solander had already died in 1782. It is also quite clear that he had L'Héritier's manuscript *Compendium Generalogium* available. In the preface to the *Hortus Kewensis* it is stated that "References are frequently made to the works of M. L'Héritier, under plants of which he has not

yet published either descriptions or figures; these are taken from communications this gentleman frequently made, during the course of printing, of everything he had prepared for the press. But, as the public will in due time be put into possession of the whole, little need be said on this subject”.

With the generic description of *Pelargonium* in *Hortus Kewensis* reference is in fact made to L'Héritier who supplied the description and as this description is essentially identical to that in the *Compendium Generalogium*, I therefore propose that the genus *Pelargonium* should be cited as follows:

Pelargonium L'Hérit. in Ait., Hort. Kew. ed. 1, 2: 417 (1789).

AUTHORITIES FOR THE SPECIES OF PELARGONIUM IN AITON'S *HORTUS KEWENSIS*

It is noteworthy that the specific descriptions of pelargoniums in the *Hortus Kewensis* are repeated verbatim from the *Compendium Generalogium* of L'Héritier. With the specific descriptions reference is made to the numbers of the species in the *Compendium Generalogium* as well as to the figures in *Geraniologia* . . . (1792). Only in the case of *P. hirsutum* (species number 1) no mention is made of the works of L'Héritier, because this species was not included in L'Héritier's works. On the other hand, *P. cordatum* which is included in the *Compendium Generalogium*, was not taken up in the *Hortus Kewensis*. The extant *Compendium Generalogium* consists of 64 pages, but apparently some pages are lost, because the *Hortus Kewensis* refers to an additional six species which were supposed to have been included by L'Héritier.

Against this background the author citation of the *Pelargonium* species in the *Hortus Kewensis* can be considered. Because the specific descriptions agree verbatim with those of L'Héritier, and because it is clear that they were supplied by L'Héritier, I am of the opinion that the latter should receive recognition, as in the following example:

Pelargonium pinnatum (L.) L'Hérit. in Ait., Hort. Kew. ed. 1, 2: 417 (1789).

In the case of *P. hirsutum*, the species which was not included in the *Compendium Generalogium*, the author citation should be as follows:

Pelargonium hirsutum (Burm. f.) Ait., Hort. Kew. ed. 1, 2: 417 (1789).

TYPIFICATION OF THE GENUS *PELARGONIUM*

It is amazing that such an internationally known genus as *Pelargonium* has apparently never been typified. Nowhere in the literature could I find any indication that a type species for *Pelargonium* has ever been designated.

The choice of a type species for a genus is arbitrary, but it must be within the framework of Article 7 of the International Code of Botanical Nomenclature (1978 edition) which states amongst others that: “The type of a name of a taxon

assigned to a group with a nomenclatural starting point later than 1753 is to be determined in accordance with the indication or description and other matter accompanying its first valid publication''.

In this instance the *Hortus Kewensis* is the first valid publication of the genus *Pelargonium*, and as lectotype species, I propose *Pelargonium cucullatum* (L.) L'Hérit. in Ait., Hort. Kew. ed. 1, 2: 426 (1789). (*Geranium cucullatum* L., Sp. Pl. ed. 1, 2: 677 (1753)). The generic description in *Hortus Kewensis* applies entirely to *P. cucullatum*. Furthermore, this species was one of the first pelargoniums to be collected and described, and it is one of the most important ancestors of garden hybrids which are today cultivated all over the world.

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BOOK REVIEWS

BIBLIOGRAPHY OF SOUTH AFRICAN BOTANY (UP TO 1951), by A. A. Bullock, edited by O. A. Leistner with pp. iii, 1–194. Flora of Southern Africa. Government Printer, Pretoria, 1978. Limp cover R4,50 (R5,50 abroad).

A. A. Bullock's *Bibliography of South African Botany (up to 1951)* is another part in the *Flora of Southern Africa* series. The compiler certainly cast his net wide when setting out on this mammoth venture, for physiological, biographical, geological, historical, anatomical and palaeobotanical, as well as the expected taxonomic references to Gymnosperms, Angiosperms, Pteridophytes and Bryophytes, are included. There are two parts; an author index and a taxonomic index, covering literature published up to 1951. Although no starting date is mentioned, it seems that most (but by no means all) the pre-Linnaean writings on South Africa flora are included. Obviously there are gaps as the author probably never set out to produce a wholly complete work, but there are also some curiously irrelevant entries such as "E. E. M. Loock, 1947, *Eucalyptus* species suitable for the production of honey in South Africa." Does such a paper really have any bearing on South African botany? Nevertheless, this is going to be an exceptionally useful reference work, especially to taxonomists.

It is now almost a hundred years since MacOwan and Bolus published their *Catalogue of Printed Books and Papers relating to South Africa*. (Pt. 1, Botany, 1882). Bullock's work takes over from there as a worthy successor and I have no doubt that those who are wise enough to purchase this most reasonably priced book will find their copies well thumbed ere long.

J. P. ROURKE

GREENHOUSE MANAGEMENT, by J. J. Hanan, W. D. Holley and K. L. Goldsberry, with pp. xiv + 530, 283 figures and 117 tables. ISBN 3-540-08478-9. Berlin-Heidelberg-New York: Springer-Verlag, 1978. Volume 5 in the Advanced Series in Agricultural Sciences, co-ordinating editor B. Yaron. Cloth DM 94, US \$47.00.

The book is bound neatly in a hard cover of 170 × 250 mm in size. Good quality paper is used and the letter printing is of a high standard. Unfortunately many of the photographic prints are rather poor which detracts from the overall appearance of the book and is not expected from a book in this price class.

The subject of greenhouse management is presented in 12 chapters. After a short introductory chapter, dealing amongst other things with the size of the greenhouse industry, world wide, a whole chapter is devoted to the subject of light. This subject is treated in an excellent manner. After discussing the characteristics of light and solar energy the principles and practices of supplemental irradiation are covered.

The third chapter is devoted entirely to greenhouse construction. This aspect is covered in great length and detail. Some aspects are possibly treated in too great a detail and figures giving specifications for items such as types and lengths of nails could have been omitted. The following 7 chapters deal with the factors affecting plant growth and production in the following order: temperature, water, soils and soilmixtures, nutrition, carbondioxide and pollution, insect and disease control, and chemical growth regulation. These chapters are well written, maintaining a proper balance between theory and application. Tables, figures

and plates are used with discretion to further explain the text. All statements are substantiated by reference to original research papers. Special mention should be made of the extensive list of references at the end of each chapter, many of which are difficult to obtain in a library. To round off the subject of greenhouse management the last two chapters are dealing with business management and marketing.

A number of printing errors were noted; for example the page reference in the index under 4.4 Cooling of Greenhouses should be 175 and not 157, the y-axis for Fig. 3.29 and 3.30 are omitted while there are no dimensions stated on the y-axis for Fig. 3.31.

Despite the few points of criticism the authors succeeded very well in integrating relevant parts of three different disciplines, i.e. biology, engineering and economics. It is possibly the best book in its class today. The book has world-wide application and although principally aimed at the professional horticulturist it can be used to great advantage by students in advanced courses in horticulture.

G. JACOBS

MEDICINAL PLANTS OF WEST AFRICA, by Edward S. Ayensu with pp. 330. Michigan, Reference Publications, Inc., August 1978. US \$29.95.

This is a pleasantly produced book of manageable size and clear print, together with 127 monochrome illustrations of difference species and of varying quality. Included is a glossary of medical terms, though I must admit never to have heard of alexiteric, antipsoric, acrochordon or bechic (from the first double page only); nor antilith, but I rather like that one. Then follows a bibliography, which I imagine is reasonably exhaustive of the subject, a very adequate medicinal index and a species index. The text is arranged in alphabetical order of families—as in Watt and Breyer-Brandwijk's larger book on Southern and Eastern Africa. Both books include the native names but there the resemblance ends, for the present volume follows a set pattern; for each species the countries where it is used are listed, together with its local names, followed by lists of disorders treated. There is no description or discussion of evidence, true value, popularity or any toxic properties. As an example, Diabetes Mellitus appears in the index under 5 species: (1) Leaf of *Bridelia ferruginea* (tea), (2) *Costus schlechteri*, "part not cited", (3) *Musa sapientum* ("unripe fruit, with other drugs"), and so on.

There is no doubt that potent medicines derived from plants are still to be discovered [consider the fairly recent *Rauvolfia* alkaloids, vincoblastin from *Vinca* spp. and steroids from diosgenin (*Dioscorea* spp.)] but I cannot see how this book is going to be of much help except as a catalogue. In fact a catalogue, large and probably accurate, is what it is and, as far as I can judge, it contains no original work but relies entirely on the works quoted in the bibliography.

The author is himself a Ghanian, a botanist of world renown and now Director of Endangered Species Program at the Smithsonian Institute. He is thus well able to judge the accuracy of his sources. The book is essentially for reference and includes few South African species, (eg. *Abrus precatorius*, *Kigelia africana*) though many genera that are represented here also (eg. *Acacia*, *Adenia*, *Albizia*, *Amaranthus*, *Asparagus*, etc.).

This work fills a gap and shows great industry but will probably be necessary only to the large libraries and research workers in this field.

W. P. U. JACKSON

THEORIES AND TECHNIQUES IN VEGETATION ANALYSIS, by R. E. Randall with pp. 61 and illustrations. Oxford University Press, 1978. R4,16.

This slim volume is one of the titles in the series "Theory and practise in geography" and thus the topics included are limited to those of interest to the geographer. These topics could have formed the basis of a valuable text but Randall's attempt at a synthesis is unimpressive.

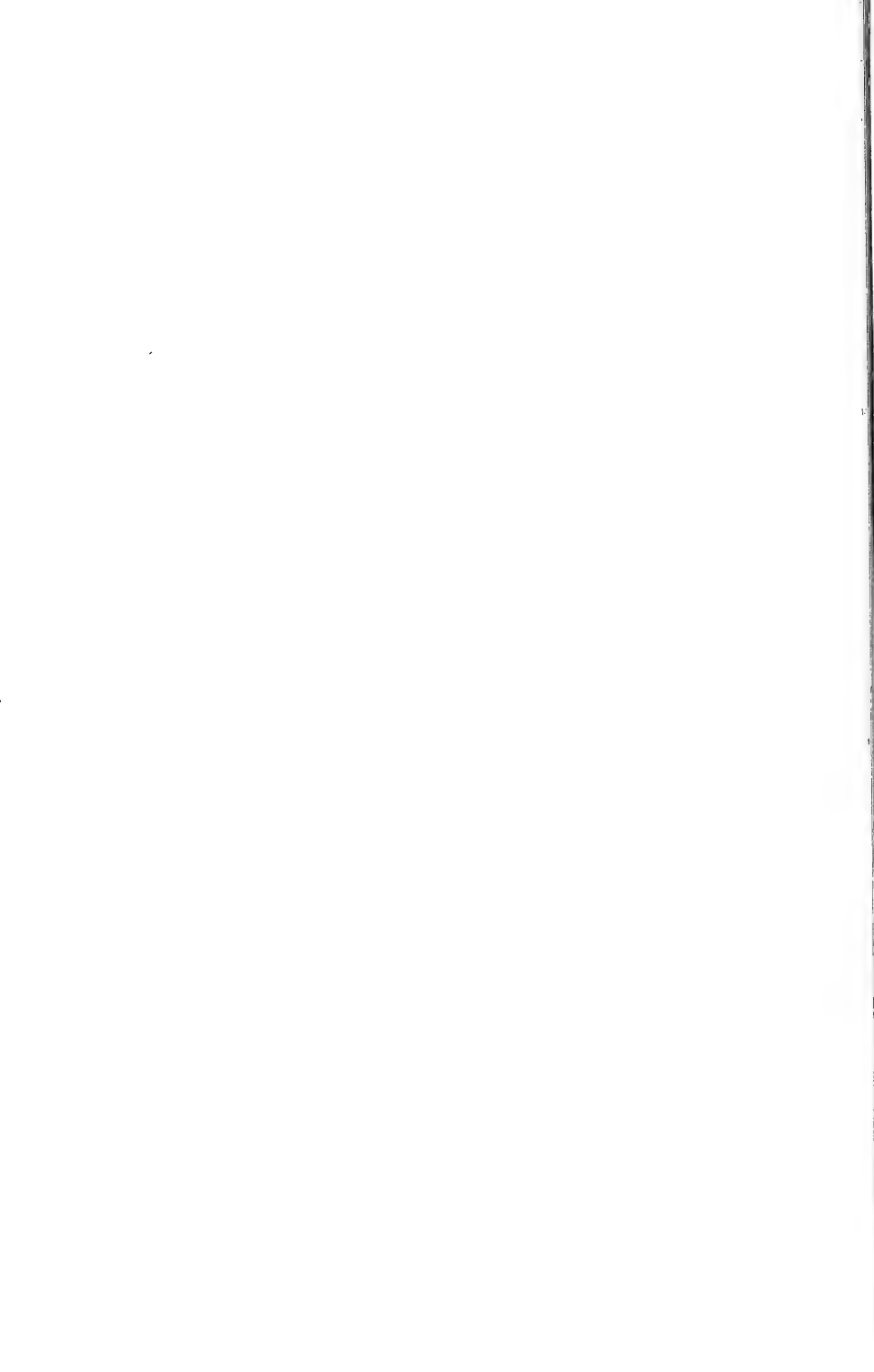
The author has used a very poor system of subdivisions and therefore the reader is unable to rapidly identify specific topics. For example cover and frequency are discussed in their own sections whereas density is discussed under "types of data-estimations". Permanent plots are briefly mentioned under "Transects". Why does the author not use more generally accepted terms as headings? For example, why not use "Polythetic" instead, of "Fusion"; "Floristic approaches" instead of "Species characteristics". The poor subdivisions are not aided by the absence of an index. The reference list is hardly adequate. 25 of the approximately 180 references are from the 1970s and then 5 of these 25 are publications by the present author. The two most recent publications (1976) are both by the present author.

This book appears to be aimed at undergraduates and yet it often presupposes knowledge of vegetation science. For example (1) in Chapter 3 concepts are introduced without clarification (synecology, continuum, ordination), (2) Figs 4 and 5 have very poor captions (I would think that Fig. 5 is especially meaningless to any undergraduate) and (3) in describing the Zurich-Montpellier method the author states that subjective weightings are given to each plant (nowhere has the author mentioned what this subjective weighting is, and he has not described the Braun-Blanquet cover-abundance scale). It would be possible to cite numerous other examples.

Chapter 2 contains a diverse range of topics (e.g. "land-use", "indicator species", "ecosystem studies", "vegetation evaluation", "pollution", "road networks" and "vegetation dissemination"), and can only be of value in knowing what topics in vegetation science are of interest to geographers. Chapter 3 is a dry treatment of the history and development of vegetation study. Numerous ideas are introduced without much clarification and numerous works are cited. Chapters 4, 5 and 6 (the theories and techniques) are the most useful sections of the book but are spoilt by the problems mentioned above, i.e. the poor subdivisions and the presupposition of a knowledge of vegetation science. The author is obviously unfamiliar with the Zurich-Montpellier technique. For example, in his description of the technique, he incorrectly states that "within each uniform area randomly chosen, several relevés are made".

The need for a slim volume on the theories and techniques in vegetation science remains.

B. M. CAMPBELL



BIOLOGY AND SYSTEMATICS OF GALAXIA (IRIDACEAE)

PETER GOLDBLATT

(B. A. Krukoff Curator of African Botany, Missouri Botanical Garden, St. Louis, Missouri, U.S.A.)

ABSTRACT

Galaxia is a small genus of Iridaceae-Iridoideae, endemic in the winter rainfall region of southern Africa. Twelve species in two subgenera are included in the genus, a marked increase in the previously recognized five species and one variety. Four species in this treatment, *G. barnardii*, *G. alata*, *G. luteo-alba* and *G. stagnalis* are new to science. Geographic speciation appears important in subgenus *Eurystigma* while ecological speciation is significant in subgenus *Galaxia*. Important evolutionary trends in *Galaxia* are aneuploid in chromosome number and development of autogamy.

UITTREKSEL

BIOLOGIE EN SYSTEMATIEK VAN GALAXIA (IRIDACEAE)

Galaxia is 'n klein genus van die Iridaceae-Iridoideae, wat endemies is in die winter reënval streek van Suid-Afrika. Twaalf spesies in twee subgenera word in die genus ingesluit, 'n groot vermeerdering van die vorige erkende vyf spesies en een variëteit. Vier spesies in hierdie hersiening, *G. barnardii*, *G. alata*, *G. luteo-alba* en *G. stagnalis* is nuut. Geografiese spesiasie skyn van betekenis te wees in die subgenus *Eurystigma* terwyl ekologiese spesiasie van belang is in subgenus *Galaxia*. Belangrike neigings in die evolusie van *Galaxia* is aneuploïde verandering van die chromosoomgetal en ontwikkeling van autogamie.

INTRODUCTION

Galaxia is a small genus of Iridaceae which is confined to the southern and western portions of the Cape Province of South Africa (Fig. 1), an area with a mediterranean climate. The genus consists exclusively of small, stemless plants of a *Crocus*-like habit, which produce a cluster of leaves and flowers near ground level. *Galaxia* was believed at one time to be allied to *Crocus*, *Romulea*, and *Syringodea*, genera with similar growth form, either constituting a separate subfamily Crocoideae (Pax, 1888) or a subtribe of Sisyrinchieae (Diels, 1930). However, following suggestions by Arber (1921) *Galaxia* has been shown to belong to subfamily Iridoideae (Lewis, 1954) and to be related to *Moraea* and *Homeria* (tribe Homeriinae) (Goldblatt, 1976b). The evolution of *Galaxia* thus parallels that of the similarly specialized *Crocus*, *Romulea* and *Syringodea*. *Galaxia* was described in 1782, yet has remained largely misunderstood until

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today owing to paucity of collections and to difficulties in preserving the extremely fragile flowers. Twelve species are admitted in this treatment which represents a twofold increase in the number of taxa currently recognized in herbaria. Four new species are described in this paper, while three more are restored to recognition.

RELATIONSHIPS

The affinities of *Galaxia* were at one time believed to lie with *Crocus*, *Syringodea* and *Romulea* of subfamily Ixiodeae which, like *Galaxia*, comprise mostly stemless plants with small flowers borne at or near ground level. Pax (1888) even included these three similarly reduced genera in a single subfamily, Crocoideae. Arber (1921) pointed out the similarity in leaf anatomy of *Galaxia* to the Iridoideae, specifically to *Moraea*. Later, Lewis (1954) quite convincingly showed that *Galaxia* belonged to this subfamily, and to *Moraea* and its allies in particular by virtue of its leaf, corm and flower structure. This treatment was supported by myself (Goldblatt, 1971) on cytological grounds and by Schulze (1971) on the basis of pollen structure and *Galaxia* is now included in subtribe Homeriinae (Goldblatt, 1976b). This predominantly African grouping comprises *Moraea*, *Homeria*, *Hexaglottis*, *Barnardiella*, and *Gynandiris*, and *Galaxia* shares with these a secondarily bifacial leaf and characteristic corm. The corm in subtribe Homeriinae consists of a single swollen internode with a primordial apical bud at its apex. Roots emerge from the base of the apical bud when growth is initiated. This stands in marked contrast to the usual several internode corm of subfamily Ixiodeae, which includes *Crocus* and *Romulea*, where roots emerge from the corm base and not from the apical bud base. The corm in Ixiodeae is usually derived from the base of the flowering stalk (De Vos, 1977) though in a few genera from an axillary bud, while the corm of Homeriinae always develops from an axillary bud.

Cytologically *Galaxia* also accords with the Iridoideae and it has the usual large chromosomes of this subfamily (Goldblatt, 1971) in contrast with the generally small chromosomes of Ixiodeae (where *Crocus* is however a notable exception). *Galaxia*, with chromosome numbers of $n = 9, 8$ and 7 (Goldblatt, 1980) seems most closely related to *Moraea*, in which $x = 10$ is basic and lower numbers of $n = 9, 8$ and 6 occur (Goldblatt, 1976a). A derived base number of $x = 6$ occurs in other genera of Homeriinae, except *Barnardiella*, with $x = 10$.

Morphologically, *Galaxia* stands apart from other members of Homeriinae where it is the only genus which consistently has a perianth tube (a perianth tube is also found in two species of *Moraea* and one of *Hexaglottis*) and also in general habit. The inflorescence found in *Galaxia* with its sessile flowers is difficult to interpret but seems to be similar to the basic type in Homeriinae.

The reduced habit of *Galaxia* is matched in the four species of *Moraea* section *Acaules*. These species also lack an aerial stem and have leaves and

flowers borne at ground level. Section *Acaules*, with a base number of $x = 10$, includes *M. falcifolia* Klatt as well as the well-known *M. ciliata* (L.f.) Ker, but these species have pedicellate flowers in several-flowered inflorescences. Nevertheless, section *Acaules* is most likely the closest related group to *Galaxia*, and the two may well have had a common ancestor in some extinct species of *Moraea*.

GEOGRAPHY

Galaxia is restricted to the winter rainfall region of the Cape Province of South Africa and, in fact, occurs primarily in the Cape Floristic Region. Four species of *Galaxia* occur in central Namaqualand, north of the area usually included in the Cape Floristic Region. One of these, *G. fugacissima*, a Cape species extends locally almost as far north as Springbok and *G. ciliata* a

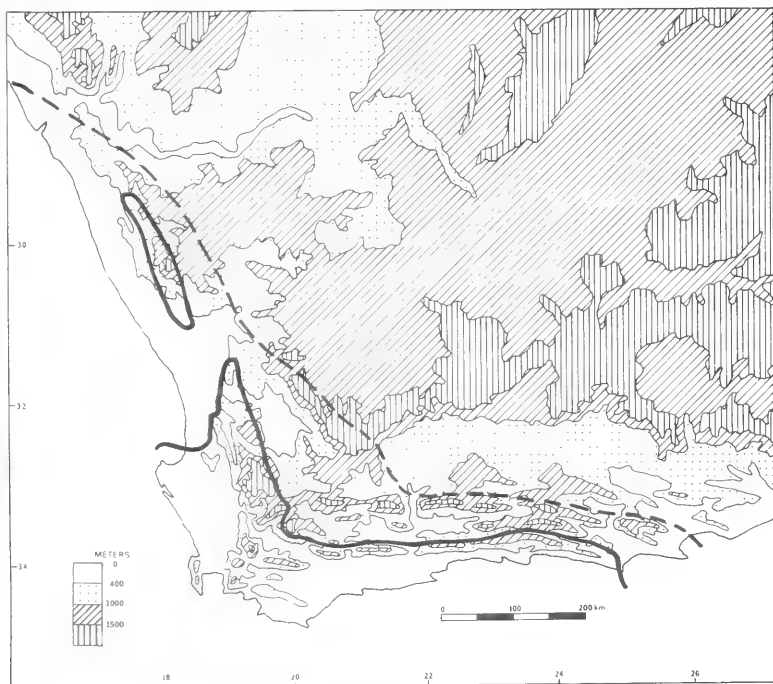


FIG. 1.

Range of *Galaxia* in South Africa. The interrupted line indicates the approximate limits of the winter rainfall region.

Namaqualand endemic, occurs between Nuwerus and Spektakelberg. This is considerably north of the area usually considered as comprising the Cape Floristic Region (Goldblatt, 1978) and well north of the Kamiesberg in southern Namaqualand which Weimarck recognizes as the northernmost limit of Cape Flora. At Spektakelberg *Galaxia* occurs amongst several typically Cape taxa and in a community that must be regarded as an outlier of the Cape Flora. Typical Cape taxa on the Spektakelberg include *Diosma acmaeophylla* (Rutaceae), *Cliffortia* (Rosaceae), *Struthiola* and *Passerina* (Thymelaeaceae), three species of *Lobostemon* (Boraginaceae), *Erica plukenetii*, *Restio sieberi*, and several Iridaceae that occur well to the south, some on the Cape Peninsula, including *Geissorhiza aspera*, *Ixia erubescens*, *Hexaglottis lewisiae*, *Moraea tenuis* and *M. ciliata*.

The total range of *Galaxia* (Fig. 1) extends southward from Spektakel Pass in Namaqualand, through the Kamiesberg to the western Cape, and into the southern Cape with the most eastern record from the Humansdorp district. With the exception of the Caledon area, the southern Cape is poor in species and the centre of the genus clearly lies to the west (Fig. 2). Species concentration is highest in the Worcester and Wuppertal grid squares (Fig. 2) with six species in each area. The Cape Town and Caledon grid squares have five species in each. Local areas of high species numbers are the northern Cape Peninsula, around Cape Town, where there are five species and the Cedarberg and Cold Bokkeveld where four species occur in close proximity.

ECOLOGY AND BIOLOGY

Habitat

The landscape of the southern and western Cape Province is considerably dissected, with high mountain ranges lying parallel to one another and to the coastline. There are thus a series of valleys and mountains from the coast to the interior, each progressively drier than the one nearer the coast. Valleys and lower mountain slopes generally have a clay soil derived from shale and the mountains a coarse sandy soil (Dahlgren, 1968; Goldblatt, 1976b, 1978a). Thus species that tend to be montane grow on sand while lowland species grow on clay soils. There are extensive deposits of alluvial sands along the west coast and there are accordingly some exceptions to this generalization.

Typically clay-loving species are *Galaxia versicolor*, *G. barnardii* and *G. variabilis* while *G. fugacissima* and *G. ovata* occur on clay only in the well-watered, southern part of their ranges. These species grow either in exposed sites with little other plant growth or in communities dominated by small ericoid-leaved shrubs of either coastal fynbos or renosterbosveld (Acocks, 1953). *Galaxia ciliata* grows on clay in a similar habitat in Namaqualand, where clay soils are uncommon, a fact probably accounting for the rarity of this species.

Species that prefer sandy soils either grow on the mountains or in lowland alluvial sand. Several montane species occupy a very characteristic habitat,

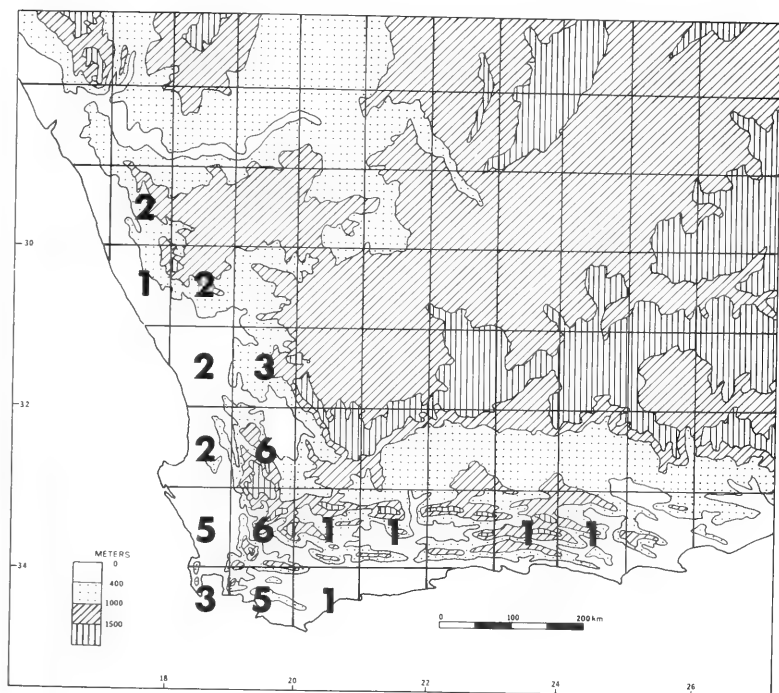


FIG. 2.

Species concentration of *Galaxia* given as number of species in each geographical one degree square.

namely very shallow soil on moist shelving slabs of rock, a situation where these small plants do not become crowded out and over-shadowed by the generally robust mountain vegetation. Species characteristic of these rocky seeps are *Galaxia luteo-alba*, *G. cirina*, occasionally *G. ovata* (often found in lowlands on clay soil) and sometimes *G. fugacissima*. *Galaxia stagnalis* may also be found on rock shelves, but only when these places are unusually wet, and more often this species grows in shallow temporary pools or in the bed of small seasonal streams.

Sand-loving species are also found in the open, but then mainly in seasonally very wet sites with poor drainage. Such places tend to have scanty vegetation and thus allow growing space for *Galaxia*. Species characteristic of this habitat are *Galaxia alata*, *G. grandiflora*, *G. fugacissima* and *G. albiflora*, the latter two sometimes growing together.

Floral Biology

The flowering rhythm in *Galaxia*, as in many other members of tribe Homeriinae, follows a strict pattern. Individual plants produce one or rarely two flowers at a time and each flower lasts a day only. Usually a few days elapse before a plant blooms again. Flowering is strongly synchronous in populations so that most plants flower on the same day and produce very few or no flowers on other days. Times of opening of flowers is constant for species, although somewhat influenced by external conditions such as temperature, and flowers open rapidly at particular times, and fade just as rapidly later in the day, when tepals very quickly collapse and deliquesce.

Flowers of subgenus *Galaxia* generally open in late morning, about 11h00, but earlier in *G. fugacissima*, at about 10h00, and fade at about 16h00. *Galaxia albiflora* is exceptional in opening only after 13h00 and fading shortly after 15h00. In subgenus *Eurystigma* flowers open from 11h00 to noon and fade between 16h00 and 16h30.

Observed insect visitors are small bees which are probably the most important pollinators for outcrossing species. The very bright coloured flowers are likely the major attractant for visitors, but a strong sweet scent is produced in *Galaxia fugacissima*.

As determined by greenhouse experiments, most species are self-incompatible, the rule in the southern African Iridoideae. Three important exceptions are *Galaxia albiflora*, *G. stagnalis* and some southern populations of *G. fugacissima*, all subgenus *Galaxia*. In these species parts of the fringed stigma are in contact with the anthers, and self-pollination and autogamy regularly occur. *Galaxia fugacissima* is of interest as some populations are pseudo-heterostylous. Some individuals have short styles and are autogamous while others with long styles and often shortened filaments are not autogamous (whether these are self-compatible or not is unknown). It is not known whether *G. ciliata* or *G. grandiflora* are self-incompatible or not.

HYBRIDIZATION STUDIES

Interspecific hybrids can be produced with comparative ease within subgenera but naturally occurring hybrids are rare, having been observed only between *Galaxia fugacissima* and *G. albiflora* and between *G. variabilis* and *G. citrina*. Triploid individuals ($2n = 27$) found amongst plants of *G. ovata* ($2n = 36$) and *G. alata* ($2n = 18$) growing together may also be natural hybrids, though these triploids strongly resemble *G. alata*.

Several artificial hybrids have been produced between all four species of subgenus *Eurystigma* and differences in chromosome number and karyotype between the four species of the subgenus appear not to affect ability to hybridize. The only cross not yet attempted is between *G. versicolor* and *G. variabilis*. All other possible crosses have been made and most have succeeded, exceptions being

G. variabilis \times *G. citrina* and *G. barnardii* \times *G. citrina* (in both the reciprocal crosses were successful). The results of these hybridization studies tend to confirm the close relationships of the four species of subgenus *Eurystigma*. Crosses between subgenera have so far all failed.

Only a few hybridization attempts have been made between species of subgenus *Galaxia*, as plants available did not produce sufficient flowers. Crosses between *Galaxia fugacissima* \times *G. albiflora* succeeded, confirming observations in the field.

CHROMOSOME CYTOLOGY

Cytology of *Galaxia* has formed an important adjunct to the systematic study of the genus and is reported in detail separately (Goldblatt, 1980). Contrary to previously published data (Goldblatt, 1971) $n = 9$ is probably basic in the genus, not $n = 8$. Some counts for *Galaxia* which I published earlier were incorrect and led to the erroneous assumption that $n = 8$ was basic for *Galaxia*. All species of subgenus *Galaxia* in fact have $x = 9$, with polyploidy recorded in three of the eight species, *G. ovata*, *G. stagnalis*, and *G. alata*. In subgenus *Eurystigma* there is an unusual amount of chromosomal variation with $n = 8$ in *G. barnardii*, *G. citrina* and *G. versicolor*, both of the latter having some populations with $n = 7$. *G. variabilis* consistently has $n = 7$, and has a quite different karyotype from forms of *G. versicolor* with $n = 7$. Chromosome numbers are given in species descriptions, but documentation and descriptions of karyotypes are given elsewhere (Goldblatt, 1980), and are not repeated.

SPECIATION

The four species of subgenus *Eurystigma* have separate or almost separate geographical ranges (Figs 3, 6) and appear to have evolved from a common ancestral stock in isolation from one another. Three in particular, *Galaxia barnardii*, *G. versicolor* and *G. variabilis*, seem to be vicarious species which grow in similar ecological situations in their different ranges. The fourth species of the subgenus, *G. citrina*, is clearly very closely related to *G. variabilis*, but the two have different chromosome numbers and separate ecological requirements and although their ranges overlap to a small extent they seldom grow together. Hybrids have, however, been noted between these two species at three sites. Differences in chromosome number and in ecology are the probable isolating mechanisms which keep the two species distinct.

Species of subgenus *Galaxia* in contrast are often sympatric and frequently at least two species grow in the same general area. Each species of the subgenus however seem to have subtly different ecological preferences. Floral morphology is usually identical and hybridization may occur. Recorded hybrids between *G. fugacissima* and *G. albiflora*, both $n = 9$, are sterile, as are suspected hybrids

between *G. alata*, $n = 9$ and *G. ovata*, $n = 18$. Ecological speciation is implied in the subgenus, with hybrids that occur between different species growing near one another sterile either by virtue of the different ploidy levels of the parents, or for other unknown reasons.

The two smallest flowered species of subgenus *Galaxia*, *G. albiflora* and *G. stagnalis* are autogamous and would appear to have evolved recently. *G. albiflora* is strictly coastal in distribution, growing mainly on recent alluvial sands while *G. stagnalis* grows in the ecologically specialized habitat of vernal pools and seeps in the northern Cedarberg, and it is one of the earliest blooming species of the genus.

HISTORY OF *GALAXIA*

Although *Galaxia* has been known since the later Linnaean period, it has remained very poorly understood. When the genus was described by Thunberg in 1782, two species were already known, both having been sent to Linnaeus from the Cape the previous decade. The two species were, however, published only after Linnaeus' death, when his son (Linnaeus fil., 1781), described *Ixia galaxia* from a Sparrman collection and *I. fugacissima* from a Thunberg collection. The following year Thunberg described the genus *Galaxia*, recognizing the same two species but under different names with *Ixia galaxia* as *G. ovata* and *I. fugacissima* by the new name, *G. graminea*, the latter superfluous and therefore illegitimate. In fact, Thunberg knew a third species, the pink-flowered *G. versicolor*, which, like the previous two grew on the Cape Peninsula, but he included broader- and narrower-leaved forms of this species separately as var. *corollis violaceis* under *G. ovata* and *G. graminea* respectively.

Subsequent collecting in the Cape during the late eighteenth and early nineteenth centuries resulted in the discovery of several more species. Many of these new collections were clearly cultivated in Europe, a fact known from the excellent illustrations published by Jacquin in the *Icones Plantarum Rariorum* in 1795, by Ker in *Curtis's Botanical Magazine* from 1800 to 1812 and by Andrews in the *Botanists Repository* in 1800 and 1801. In spite of the availability of living plants and good published illustrations, *Galaxia* was misunderstood at this period. Jacquin's illustration in *Icones Plantarum*, tab. 291 includes three plants, all referred to as *G. ovata* although only one, the yellow-flowered plant, represents this species. The other two are forms of the species later named *G. versicolor*. Salisbury (1812) recognized the two remaining plants figured by Jacquin as different from *G. ovata* and he assigned each a different name; neither, however, was described and thus *G. mucronularis* and *G. versicolor* of Salisbury are nomina nuda. Klatt validated one of Salisbury's names, *G. versicolor*, in 1863. This same taxon was validly described by Ker in 1812 as *G. ovata* var. *purpurea*, which Klatt raised to specific level in 1882, evidently believing *G. versicolor* and *G. purpurea* to be distinct. Other species described during the period were *G.*

grandiflora Andr. and *G. ciliata* Pers. both from good illustrations of these taxa, and *G. multiflora* Spreng, which is not distinguishable from *G. ovata*.

Understanding of *Galaxia* remained poor throughout the nineteenth century. As treated by Baker (1892, 1896) in his *Handbook of the Irideae* and in *Flora Capensis*, two major treatments of Iridaceae produced in the 1890's, *Galaxia* was recognized as comprising only two species, *G. fugacissima* and *G. ovata*. Baker did in addition admit two varieties of *G. ovata*, var. *versicolor* and var. *ecklonii* (both *G. versicolor*).

The South African botanist and specialist in Iridaceae, G. J. Lewis, discovered and described three more species in the period 1935–1945, namely *G. albiflora*, *G. variabilis*, and *G. citrina*. Lewis (1950) continued to recognize *G. versicolor* as a variety of *G. ovata* so that although in fact eight of the 12 species of *Galaxia* admitted in this treatment were known by the mid-twentieth century, only five species and a variety are currently recognized in herbaria.

MORPHOLOGY

Rootstock

The rootstock is a corm of the *Moraea* type (Goldblatt, 1976b) consisting of a single swollen internode with a primordial bud at its apex. Corms of species of *Galaxia* are generally small, and usually less than 7 mm in diameter. The tunics covering the corms may however accumulate from year to year so that the corm can appear much larger.

Tunics of most species are similar, consisting of concentric layers with prominent dark brown vertical ridges, often woody in texture alternating with lighter coloured grooves of fine fibres sometimes covered by a slightly sticky exudate. As the tunics age, the layers begin to disintegrate, forming a loose and progressively more fibrous network. Corms of *Galaxia ciliata* stand out, as tunic layers of previous years tend to accumulate and form particularly large fibrous masses, losing all vestige of their original ridged structure.

The only other corm type found in *Galaxia* is that of *G. alata*, which has a spindle-shaped corm with a tunic of pale, bone-like material, in which there is no trace of fibres. The tunics are prominently winged rather than ribbed as in other species (Fig. 11).

Vegetative reproduction frequently occurs by formation of small cormlets around the main corm which produce separate plants in the following year. Cormlets are also sometimes produced in the axils of floral bracts if fertilization of the flower fails to occur. This phenomenon, first noted by Sprengel (1820) when he described *G. multiflora*, has been observed in the wild in *G. ovata* and *G. alata* and in the greenhouse for several more species including *G. fugacissima*, *G. variabilis*, *G. versicolor*, and rarely in *G. stagnalis* (which is generally autogamous).

Foliar Structures

Cataphylls: These envelop the underground part of the stem and are transparent and entirely sheathing. Occasionally the uppermost cataphyll may become green and even extended and with a free apex. In this case it is essentially a basal leaf. However, this does not happen regularly and seems to have no taxonomic significance.

Leaves: Basal leaves inserted below ground are not found in *Galaxia* except occasionally when a cataphyll becomes leaf-like. The true leaves are produced in a cluster at the stem apex, and surrounding the floral bracts. Leaves and outer floral bracts are in fact barely distinguishable except by position relative to a flower, though the leaves are generally larger.

The leaves are typically bifacial, fairly short and channelled, with an obtuse, apiculate apex. *Galaxia ovata*, and its allies *G. luteo-alba*, *G. stagnalis*, *G. ciliata* and *G. grandiflora* have particularly short leaves that are flat or only slightly channelled, and in the two first mentioned species the true leaves are ovate and prostrate.

A second important leaf type is found in *Galaxia fugacissima* where the distal part of the leaves and outer bracts is unifacial, sometimes for half the total length. Unusual leaves are found in *G. alata*. Here the leaf is terete in the distal half and often somewhat succulent.

The leaf margin is generally minutely ciliate and often visibly thickened and hyaline, which is particularly noticeable in *Galaxia ovata* and *G. luteo-alba*. In *G. luteo-alba* the cilia are very long, and in *G. ciliata* the leaf margins are almost villous. Cilia are distributed in a single row in all but *G. ovata* where they may either be uniseriate or densely and randomly arranged.

Inflorescence

The typical inflorescence of the Iridoideae is a corymbose cyme enclosed by two opposed bract-like spathes from which the flowers are produced serially borne on long pedicels. The situation in *Galaxia* does not conform to this general pattern, and the true relationship of the inflorescence here to the probable ancestral condition is obscure. Each flower in *Galaxia* is enclosed by two bract-like structures, an inner, transparent membranous bract entirely enclosed by a much larger leaf-like bract. These two together may represent the opposed spathes of other Iridoid genera, or a single spathe and a true bract. It seems, however, unnecessary to try and relate the inflorescence terminology of other Iridoideae to *Galaxia*. Instead I prefer not to give the inflorescence a formal name, and will simply regard the foliar structures subtending the flower as bracts whether leaf-like or not.

The Flower

The flower is similar in form in most species, is shortly stalked and consists of a well-developed perianth tube, the function of which is to raise the flower above

the leaves, and six spreading tepals. The tube itself is funnel-shaped in all but *Galaxia barnardii* where the tepals spread horizontally from a cylindrical tube. The tepals are subequal in size or those corresponding to the outer whorl may be slightly larger, but similar in shape.

All species of subgenus *Galaxia*, except *G. albiflora* and some individuals of *G. alata*, have flowers of a similar size and yellow colour, *G. grandiflora* standing out as somewhat larger. The bicoloured white and yellow flowers of *G. albiflora* are by far the smallest in the genus and when fully open, are about 20 mm across with individual tepals ± 10 mm long. *Galaxia alata* is the only species of this subgenus in which both yellow or white flowers occur, though yellow is more common.

Flower colour is more varied in subgenus *Eurystigma*, being pink-purple with a yellow and dark centre in *G. versicolor* and purple with an almost black centre in *G. barnardii*. *Galaxia citrina* has yellow flowers occasionally with black markings in the throat, while *G. variabilis* may have pink, yellow, orange or white flowers, with a yellow centre.

Androeceum

The filaments are inserted at the apex of the narrow part of the perianth tube and united either entirely or for most of their length except in *Galaxia luteo-alba*, which stands out in having spreading filaments united only at their base. In other species of subgenus *Galaxia* the filament tube is cylindrical and complete, with anthers sessile on the filament tube or the filaments may be free for ± 1 mm, as in some forms of *G. fugacissima* and in *G. stagnalis*. In subgenus *Eurystigma* the anthers are essentially sessile on the filament tube in *G. variabilis* and *G. citrina*, but quite conspicuously stalked in *G. versicolor* and *G. barnardii* where the free parts of the filaments curve outwards. The filament tube in these last two species is unusual in being somewhat swollen shortly above the slender base.

The anthers are typical of all Irideae in being linear-oblong, extrorse and loculicidal. Dehiscence occurs shortly after the flower opens and pollen remains in place until disturbed by an insect visitor. In *Galaxia albiflora*, the short-styled forms of *G. fugacissima* and *G. stagnalis*, the stigma is in direct contact with the anther and in these species only does self-pollination occur.

Gynoeceum

The ovary is similar in all species, being small and barrel-shaped. It is entirely enclosed by the membranous inner bract. The filiform style extends the length of the perianth and filament tubes, and divides above or at the level of the anthers into three very short branches. Each style branch expands to form the broad stigma lobe. In most species the stigma is horizontal, and the radial margins curve upward to stand \pm erect.

The stigmas vary substantially in the two subgenera, being irregularly fringed (fimbriate) in subgenus *Galaxia*, and entire in subgenus *Eurystigma*. In the latter the style branches are sometimes held together laterally by delicate membranous connections, but more often are quite free. In newly-opened flowers the stigma lobe is often upright and appressed to the erect radial margins, gradually opening horizontally.

Fruits and Seeds

There is little difference in the capsular fruits of *Galaxia* species. Ripe capsules are generally 7–9 mm long and ovoid, and somewhat truncate at the apex. The seeds are numerous and dark, and angular to irregularly rounded.

SUBGENERIC CLASSIFICATION

Species of *Galaxia* fall into two clearly defined groups to which subgeneric status has been assigned. The first, subgenus *Galaxia* includes all the species with fringed stigmas (Fig. 10) and obsolete stigma crests. All eight species of the subgenus have yellow or white flowers. Basic chromosome number is $x = 9$ (Goldblatt, 1980) and most species are diploid. *Galaxia stagnalis* and most populations of *G. ovata* are tetraploid, $2n = 36$, while a population of *G. alata* is triploid, $2n = 27$.

The remaining four species of the genus are assigned to subgenus *Eurystigma*. In this group the stigmas are entire, and the crests often distinct. *Galaxia citrina* has yellow flowers, and the other species have either red, purple or bluish flowers, often with a yellow throat. Base number in subgenus *Eurystigma* is $x = 8$, but *G. citrina* and *G. versicolor* are heteroploid, with some populations having $n = 7$. *Galaxia variabilis* has a diploid number of $2n = 14$.

SYSTEMATICS

GALAXIA Thunberg, Nov. Gen. 50. 1782; Ker, Irid. Gen.: 70. 1827; Baker, Handbook Irid: 96. 1892 et Flora Cap. 6: 32. 1896. Type species: *Galaxia ovata* Thunb. (lectotype).

Plants small with leaves and inflorescences forming a fascicle \pm at ground level. *Corms* small and surrounded by entire or fibrous tunics usually with prominent vertical ridges, extending shortly upwards and frequently tapering to a point below. *Cataphylls* 2–3, transparent, sheathing underground part of stem, uppermost generally extending slightly above ground and green-tipped. *Leaves* clustered at stem apex; bifacial entirely, or distally unifacial or terete; ovate-oblong to linear, spreading or erect; occasionally a basal leaf is produced. *Stem* entirely subterranean or produced shortly above ground, but elongating in fruit. *Flowers* few to several, clustered together amongst the leaves and individually subtended by an inner membranous bract and an outer leaf-like bract; *perianth*

tube well developed, raising the flower above the leaves; *tepals* \pm equal and spreading; yellow, white or shades of pink to purple. *Filaments* inserted at the throat of the tube, partly to entirely united (joined at base only in one species); *anthers* oblong. *Style* slender and usually erect (declinate in one species), produced above anthers and with three short branches opposite the anthers; *style branches* apically stigmatic and fringed or entire, with radial margins minutely raised above the stigma. *Ovary* \pm sessile, ovoid, green. *Capsule* dry, sub-membranous, ovoid; *seeds* many, small, angled. *Basic chromosome number* $x = 9$, other gametic numbers $n = 18, 17, 8, 7$.

Type Species: Galaxia ovata Thunb. (lectotype).

Distribution: South Africa, Cape Province, concentrated in the southwestern Cape and extending north into Namaqualand; only in areas of mediterranean climate (Figure 1).

KEY TO THE SPECIES

- 1 Corm tunics entire, bony not fibrous, with prominent vertical wings; leaves terete distally, grooved in lower half only 11. *G. alata*
- Corm tunics fibrous, reticulate often with prominent vertical ribs and cross fibres fine, occasionally obscure; leaves channelled, flat, or unifacial 2
- 2 Cilia on hyaline leaf border at least $2\frac{1}{2} \times$ longer than width of border 3
- Cilia of leaf border minute, \pm equal to width of border, or border smooth 4
- 3 Lowermost leaves prostrate, flat; filaments free in upper $2/3$; Cedarberg to Nieuwoudtville 7. *G. luteo-alba*
- Lowermost leaves ascending or falcate (rarely prostrate), channelled; filaments entirely united; Namaqualand. 6. *G. ciliata*
- 4 Flowers white and tepals 9–11 mm long; style not reaching apex of anthers 12. *G. albiflora*
- Flowers shades of yellow, pink, purple, rarely white, and if so tepals at least 20 mm long; style usually exceeding the anthers 5
- 5 Stigma margin irregularly fringed; flowers yellow 6
- Stigma margin entire; flowers completely yellow or shades of red to purple (or white) with or without yellow centre 10
- 6 Outermost leaves ovate, obtuse, flat and prostrate; margin straight with border densely covered with cilia or cilia arranged in a single row 8. *G. ovata*
- Outermost leaves linear, lanceolate or oblong, acute or obtuse, channelled or occasionally flat, erect, falcate, occasionally prostrate; margin straight or undulate-crisped, border cilia if present never densely covering border 7
- 7 Leaves linear, or narrowly lanceolate, unifacial distally, erect to falcate 10. *G. fugacissima*
- Leaves entirely bifacial or unifacial only at apex 8
- 8 Leaves obtuse, channelled, falcate, and more than 4 mm wide, tepals 22–30 mm long 5. *G. grandiflora*
- Leaves obtuse or acute, straight, erect or spreading, channelled, and less than 3 mm wide, tepals less than 16 mm long 9
- 9 Plants occurring from the northern Cedarberg to Namaqualand in sand, wet places 9. *G. stagnalis*
- Plants occurring from the Caledon district eastwards, often on clay 10. *G. fugacissima*

- 10 Anthers sessile on filament column (or with free part of filament no more than 0,5 mm) and anthers straight 11
 — Anthers stalked for at least 1 mm, free part of filaments diverging and anthers arcuate 12
 11 Flowers yellow; tepals 18–23(–30) mm long, rarely wider than 10 mm; filament column cylindrical 4. *G. citrina*
 — Flowers shades of orange, pink to blue-purple (or white) with yellow throat; tepals 20–35 mm long, usually wider than 10 mm; filament column dilated in lower part 3. *G. variabilis*
 12 Style extending well beyond anthers; tepals cupped and only upper part spreading; anthers usually 1,5–2,5 mm, rarely to 4 mm long 2. *G. versicolor*
 — Style dividing at level of anthers, either not reaching apex of anthers or only slightly longer; tepals not cupped, spread horizontally from the base, anthers 3–3,5 mm long 1. *G. barnardii*

1. SUBGENUS EURYSTIGMA

Subgenus *Eurystigma* Goldbl., subg. nov.

Type species: Galaxia versicolor Salisb. ex Klatt.

A subgenus *Galaxia* differt stigmatibus integris, lobatis, foliis magnis, canaliculatis et floribus grandioribus saepe percoloratis.

Leaves bifacial, channelled, erect or sometimes becoming prostrate. Flowers often large, yellow or usually pink, red, or purple. Stigmas entire, lobed; radial margins erect, distinct. Chromosome numbers $n = 8, 7$.

Distribution: southwestern Cape between Nieuwoudtville and the Caledon district.

1. *Galaxia barnardii* Goldbl., sp. nov.

Tunicae cormi brunneae, fibris cancellatis, costis crassis lignosis. Folia bifacialia canaliculata, 40–60 mm longa, undulata, marginibus saepe crispis, hyalinis, ciliatis. Flores bubalini-purpurei, nigrescentes ad centrum; tubus perianthii 13–30 mm longus; tepala 15–25 mm longa, patentia. Filamenta 4–6,5 mm longa; antherae 3,0–3,5 mm, arcuatae. Stigmata integra, lata.

Type: SOUTH AFRICA, Cape, clay slopes between Eseljag and Queen Anne, Caledon district, *Goldblatt* 2499 (MO, holotype: BOL, K, NBG, PRE, S, WAG, isotypes). **Fig. 3.**

Plants solitary or growing in clumps. *Corm* tunics of brown cancellate fibres, vertical ribs often thick and woody. *Leaves* bifacial, channelled, 40–60 mm long, undulate, margins often lightly crisped, with hyaline, minutely ciliate border. *Flowers* stellate, pink-purple with a dark centre; *perianth tube* 13–30 mm long, dark-coloured; *tepals* broadly ovate, obtuse or acute, 15–25 mm long, spreading from the base, outer tepals 10–14 mm at widest point. *Filaments* 4–6,5 mm long, free for upper 1–2 mm, black or yellow; *anthers* 3–3,5 mm long, arcuate, reaching or exceeding the style branches. *Style branches* diverging at top of filaments with 3 distinct branches; *stigmas* undulate, broad, bordered by erect radial margins.

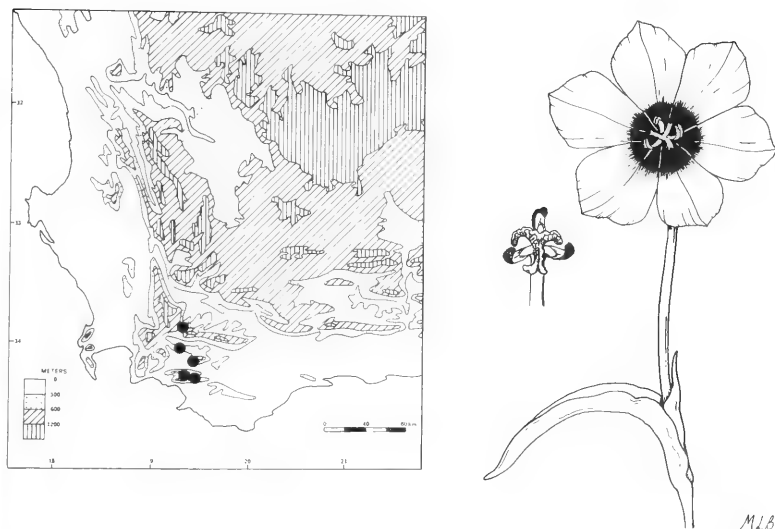


FIG. 3.

Distribution and morphology of *Galaxia barnardii* (approx. life size), with stamens and stigmas enlarged.

Chromosome number: $2n = 16$.

Flowering time: late August—September; flowers opening after 11h30, fading \pm 16h00.

Distribution: clay soils in the Caledon district in the southwestern Cape (Fig. 3).

Galaxia barnardii is closely related to the more widespread *G. versicolor*, which occurs to the north and west in a generally similar habitat. Vegetatively they cannot be distinguished, but *G. barnardii* has somewhat larger, stellate flowers, with a dark centre and spreading tepals, while *G. versicolor* has campanulate flowers with cupped tepals and usually a yellow throat. Generally the stigmas are wider in *G. barnardii*, and borne near the apex of the anthers while in *G. versicolor* the style is much longer with the stigmas borne well above the anthers. *Galaxia barnardii*, with $2n = 16$ and *G. versicolor* with $2n = 16$ and 14, appear to be vicarious species which probably evolved fairly recently from a common ancestor.

The species has not been much collected, perhaps due to its blooming well only when the surrounding vegetation is cleared. Where it occurs it is often common, and makes a brilliant display for a few weeks in September. Collections from the Swartberg near Caledon, Marloth 70503 and Guthrie s.n., have been

assigned to *G. barnardii*, though in fact critical floral features cannot be seen in these specimens. Distribution and overall flower size suggest this determination.

CAPE—3319 (Worcester): dry clay slopes N. of Villiersdorp (-CD), *Goldblatt 4006* (K, MO, PRE).

—3419 (Caledon): Swart Stomp Farm between Queen Anne and Eseljacht (-AA), *Barker 10576* (NBG), *Goldblatt 2499* (BOL, K, MO, NBG, PRE, S, WAG); S. slopes of Zwartberg near Caledon (-AB), *Guthrie s.n.* (BOL 16922), *Goldblatt 584* (BOL), *Marloth 70503* (PRE); Hemel en Aarde Valley E. of Shaws Pass (-AD), *Goldblatt 4093* (MO, NBG), *Goldblatt 4094A* (MO); Kleinriviersberg, Steinige Bergplatze, *Ecklon and Zeyher s.n.* (*Zeyher 4066*, S).

2. ***Galaxia versicolor*** Salisb. ex Klatt, *Linnaea* 32: 783. 1863. Type: SOUTH AFRICA, Cape, mountain slopes near Cape Town, *Ecklon and Zeyher 255* (B, not seen, perhaps destroyed). **Fig. 4.**



FIG. 4.

Distribution and morphology of *Galaxia versicolor* (approx. life size), with stamens and stigmas enlarged.

Galaxia versicolor Salisb., Trans. Hort. Soc. **1**: 315. 1812. nomen nudum.

Galaxia ovata var. *versicolor* Salisb. ex Baker, Handbook Irid.: 97 et Flora Cap. **6**: 33. 1896. Type: illustration in Jacquin, Ic. Pl. Rar. tab. 291, lower right figure.

Galaxia mucronularis Salisb., Trans. Hort. Soc. **1**: 315. 1812, nomen nudum.

Galaxia ovata var. *mucronularis* Salisb. ex Baker, Handbook Irid.: 97. 1892 et Flora Cap. **6**: 33. 1896. Type: illustration in Jacquin, Ic. Pl. Rar. tab. 291, lower left figure.

Galaxia ovata Thunb., var. *β corollis violaceis*, Thunberg, Gen. Nov. Pl.: 50. 1782.

Galaxia ovata var. *purpurea* Ker, Bot. Mag.: tab. 1516. 1812. Type: illustration in Bot. Mag.: tab. 1516.

Galaxia purpurea (Ker) Klatt, Erganz: 51. 1882.

Galaxia violacea Eckl., Top. Verz.: 17. 1826, nomen nudum.

Galaxia ovata var. *ecklonii* Baker, Handbook Irid.: 97. 1892. et Flora Cap. **6**: 33. 1896. Type: SOUTH AFRICA, Cape, Devils Peak, Cape Town, *Ecklon* 308 (S, lectotype; K, MO, PRE, isotypes).

Plants usually solitary. *Corm* tunics dark brown, cancellate, with vertical ribs often thick and woody and becoming prominent. *Leaves* entirely bifacial, channelled or \pm flat, lower often prostrate; obtuse to acute, often undulate and lightly crisped, 30–50 mm long and to 6 mm wide, but frequently very narrow; margins hyaline or red-flushed, border minutely ciliate. *Flowers* campanulate, shades of red, purple and pink, usually with a yellow tube and throat and deeply coloured at tepal midline above yellow throat; *perianth tube* (10–)15–22(–27) mm long; *tepals* 14–22 mm long, 7–10(–14) mm at widest point. *Filaments* 5–6 mm long, free apically for 1–1.5 mm and divergent; entirely yellow or dark in upper part; *anthers* arcuate, 1.5–2.5(–4) mm long. *Style* dilating near apex of anthers and extending well beyond them; *stigmas* entire, margin undulate, either free or contiguous at edges, radial margins erect, short.

Chromosome number: $2n = 16, 14$.

Flowering time: July–mid September; flowers open after 12h00 and fade at 16h30.

Distribution: slopes and flats in the southwestern Cape, extending from Houw Hoek and Viljoens Pass in the Caledon district to the Cape Peninsula and north to Gouda and the Tulbagh valley between Tulbagh and Waaihoek (Fig. 4).

Galaxia versicolor is variable in flower colour and marking. The distal part of the tepals are always evenly coloured, from red through purple to almost blue. The basal part of the tepals is commonly yellow with a dark band of colour separating yellow base and red-purple limb. Populations north of Stellenbosch, at Paarl, Tulbagh and Gouda, usually lack the yellow colour and the tepal base is then a very dark red to almost black. Anthers and filament column may also be dark

coloured in these forms. Most populations have broad spreading leaves reminiscent of *G. ovata* but plants from around Gouda have narrow erect grass-like leaves. Schlechter called his collections of this form *G. oxalidiflora*, but did not publish the name. Leaf structure apart, there is nothing to distinguish this form from nearby populations of *G. versicolor* and it does not appear to merit specific recognition in the light of available information.

Long confused with *Galaxia ovata*, *G. versicolor* has been known since Thunberg described it as a purple-flowered variety of *G. ovata*. Salisbury was the first to suggest specific recognition and he gave the names *G. versicolor* and *G. mucronularis* to Jacquin's figures of two forms of the species. As descriptions were not provided these names remained invalid until Klatt, in 1863, gave under the Salisbury name *G. versicolor*, a full description of a collection made by Ecklon and Zeyher. *Galaxia ovata* var. *purpurea* Ker, which was elevated to specific rank by Klatt in 1882 is exactly the same form of *G. versicolor* as Ecklon and Zeyher's type collection. Klatt's recognition of *G. versicolor* as a distinct species was strangely ignored and Baker in 1892 and 1896, and J. G. Lewis in 1950 continued to treat the species as only a variety of *G. ovata*. There is no doubt that *G. versicolor* is distinct, and it does not even seem to me closely related to *G. ovata*. Structurally the flowers differ with *G. ovata* having sessile anthers and fringed stigmas while *G. versicolor* has stalked anthers and entire, lobed stigmas. *Galaxia versicolor* is closely related to *G. barnardii* (see discussion under that species) and to *G. variabilis* though confusion with the latter is unlikely.

Galaxia versicolor is chromosomally heterogeneous (Goldblatt, 1980) with $2n = 16$ recorded in two populations from the Cape Peninsula and from plants in the Tulbagh Valley while $2n = 14$ occurs in plants from Stellenbosch, Paarl and Viljoens Pass. There are no consistent morphological differences between plants with the different chromosome numbers and the change in number is probably of recent origin with $2n = 16$ ancestral and $2n = 14$ derived by Robertsonian translocation (Goldblatt, 1980). Further counts should yield interesting data on evolution in this species and possibly also insights into the mechanism of chromosome change.

The species is fairly common between the northern Cape Peninsula and Tulbagh on clay soils, either on flats or lower mountain slopes. It generally occurs in transitional fynbos—coastal renosterbosveld, and flowers well only after the surrounding shrubs have been cleared or burnt.

Specimens said to have been collected at Hermanus (Salter 1185, 24 July 1931) must be viewed with misgiving. Either *G. versicolor* or *barnardii*, they may be mislabelled since neither species has ever been recorded near Hermanus. In addition neither species flowers as early as July and are in fact seldom found in bloom before September so far south. *Galaxia versicolor* does bloom earlier in the north, at Tulbagh and Paarl, but only from the second week of August.

CAPE—3218 (Clanwilliam): between Piketberg and Porterville (-DD), *Barnard s.n.* (BOL 31115).

—3318 (Cape Town): slopes of Devils Peak (-CD), *Ecklon 308* (K, MO, PRE, S), *Wolley Dod 1316* (BOL), *Goldblatt 2437* (K, MO, PRE, WAG); Signal Hill, *Page s.n.* (BOL 16068), *Marloth 464* (PRE), *Barker 433* (NBG), *Wilms 3676* (K); slopes of Lions Head, *Wolley Dod 1377* (K), *Pappe s.n.* (K, SAM), *Prior s.n.* (K, PRE 33487), *Barker 3872* (NBG), *Goldblatt 2434* (C, MO, WAG), 212 (BOL), *MacOwan s.n.* (Herb. Norm. 253, BOL, K, UPS); *Zeyher 5008* (SAM); Rondebosch, *Rehmann 1736* (BR); flats near Paarl (-DB), *Goldblatt 2301* (MO, S); Langverwacht, above Kuils River (-DC), *Oliver 4360* (STE); Agter Paarl road (-DD), *Loubser 2056* (NBG); clay slopes near Bottelary, *Acocks 2155* (S), *Simonsberg, Strey 498* (PRE).

—3319 (Worcester): between Breede R. and the Bokkeveld (-A), *Drège 1840* (K); flats S. of Tulbagh Station (-AC), *Barker s.n.* (NBG 88390), *Goldblatt 2309* (K, MO), 320 (BOL); Gouda commonage, *Goldblatt 2430B* (MO, PRE); hills near Gouda (Piketberg Road), *Schlechter 10706* (BOL, GRA, K, MO, PH, PRE, S), 10707 (BOL); Wabooms R., near Breede R. (-CA), *Esterhuysen 8956* (BOL).

—3418 (Simonstown): Bergvliet Farm, Cape Peninsula (-AB), *Purcell 163* (SAM); Sir Lowrys Pass (-BB), *Compton 14800* (NBG); Helderberg, Somerset West, *Parker 4228* (BOL, K, NBG, PH).

—3419 (Caledon): foot of Viljoens Pass (-AA), *Goldblatt 2490* (E, K, MO, PRE, WAG).

Without locality: Cape of Good Hope, *Thunberg s.n.* (K, S).

3. *Galaxia variabilis* Lewis, Jl S. Afr. Bot. 4: 6. 1938. Type: SOUTH AFRICA, Cape, between de Keur and Gydo, *Compton and party s.n.* (BOL, as NBG 2080/36, holotype, NBG, isotype). Fig. 5.

Plants solitary or in clumps. *Corm* tunics of brown, cancellate fibres, with vertical ribs often thickened and woody. *Leaves* entirely bifacial, canaliculate, acute, 30–60(–80) mm long, usually dark green and shiny, margins straight or undulate, hyaline, minutely cilio-serrate. *Flower* variously coloured pink, yellow or white, with a yellow throat; *perianth tube* 12–30 mm long, pale; tepals 20–35 mm long, ovate, obtuse, 10–13 mm at widest point, spreading distally, erect below. *Filaments* ± 6 mm long, free for less than 1 mm or entirely united; *anthers* 3–4 mm long, arcuate reaching just below stigmas. *Style branches* short, exceeding the anthers, *stigmas* entire, appressed to erect radial margins, later spreading horizontally and undulate.

Chromosome number: $2n = 14$.

Flowering time: September–October.

Distribution: Warm and Cold Bokkeveld, usually on clay flats, occasionally on deep sandy soil (Fig. 5).

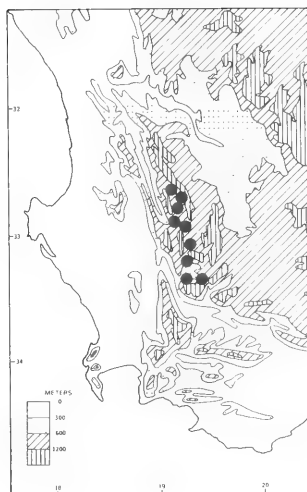


FIG. 5.
Distribution and morphology of *Galaxia variabilis* (life size).

Galaxia variabilis grows mainly on clay soils, but occasionally on deep sand, in the Cold Bokkeveld and in the Warm Bokkeveld at the foot of the Skurweberg and Hex River Mountains. Populations typically have purple flowers with a yellow throat. Chromosome number is $2n = 14$, the karyotype consisting of 7 equally sized chromosome pairs.

In a few places populations are remarkably varied; one at Skoongesig has been documented by Hanekom (collections at PRE and K); others by myself below Gydo Pass and on the northern outskirts of Ceres. Plants in these variable populations exhibit a great range in flower size, and tepal colour varies from purple through orange to yellow and white, the latter colours usually found in the smaller-flowered plants. Chromosome number in these populations is $2n = 14$, and the plants appear fully fertile, more than 95 % pollen staining with cotton blue—lactophenol while capsules develop what appear to be fertile seed.

I believe that these variable populations represent hybrid swarms of a cross between *G. variabilis* and the yellow-flowered *G. citrina* which in the southern part of its range occurs in the same general areas as *G. variabilis*. *G. citrina* has

diploid numbers of $2n = 16$ and 14 , the latter only recorded from its southern limit, Gydo Pass. The great variability in these populations would be the result of crossing between hybrids. The general observation of yellow or white flowers being smaller in these populations would be consistent with segregation of linked characters of *G. citrina* recurring in later hybrid generations.

Galaxia variabilis and *G. citrina* are certainly closely related, with very similar flowers and almost identical vegetative structures. Artificial hybrids have been made in the greenhouse, and seeds from this cross have germinated though are yet to flower. These two species can be distinguished by different habitat preferences and by flower colour and tepal size as discussed under the following species, *G. citrina*.

Galaxia variabilis, with its low chromosome number, is probably the most specialized species of subgenus *Eurystigma*. It occupies the same type of habitat as the more lowland *G. versicolor* of which it may be a vicariad. The two, though similar, can readily be distinguished, *G. variabilis* having united filaments and *G. versicolor* filaments free and divergent in the upper third.

CAPE—3219 (Wuppertal): Skoongesig, Cold Bokkeveld, (-CC), *Hanekom* 1217, 1218, 1219, 1220, 1221 (K, PRE); Cold Bokkeveld near Elands Kloof, *Leighton* 1271 (BOL); between Twee Rivieren and Leeu R., *Goldblatt* 2574 (MO, WAG); de Keur (-CD), *Loubser* 2019 (NBG), *Barker* 3125 (NBG); Leeu R. drift, *Compton* 17359 (NBG); Leeurivier, *Lewis* 1410 (SAM).

—3319 (Worcester): between de Keur and Gydo (-AB), *Martin s.n.* (NBG 59320); 9 km N Gydo Pass, *Johnson* 503 (NBG), *Lewis* 2634 (SAM); Gydo, *Leipoldt* 3839 (BOL); top of Michells Pass (-AD), *Compton et al. s.n.* (NBG 59326); northern outskirts of Ceres, *Goldblatt* 4023 (MO, WAG); flats N of Prince Alfreds Hamlet, *Goldblatt* 2592 (K, MO, NBG, S); Welvaart, base of Sanddrift Peaks (-BC), *Oliver* 5072 (MO, STE); Lakenvlei, *Oliver s.n.* (NBG 59317).

4. *Galaxia citrina* Lewis, Jl S. Afr. Bot. **4**: 4. 1938. Type: SOUTH AFRICA, Cape, between de Keur and Gydo, *Martin s.n.* (BOL, holotype; NBG, isotype). **Fig. 6.**

Plants solitary. *Corm* tunics woody, medium to dark brown, usually with prominent vertical ribs. *Leaves* entirely bifacial, canaliculate, outer 30–70 mm long, acute, smooth and shiny, margin border hyaline, minutely ciliate. *Flower* yellow, occasionally marked with black near tepal base; *perianth tube* 13–28 mm long; *tepals* narrowly ovate, obtuse-apiculate, 18–30 mm long, 11 mm at widest point. *Filaments* entirely united, to 6 mm long; *anthers* 3.5–5 mm, reaching just below stigma lobes. *Style branches* joined laterally; stigma lobes entire, appressed to the short erect radial margins, later opening outwards.

Chromosome number: $2n = 16, 14, 34$.

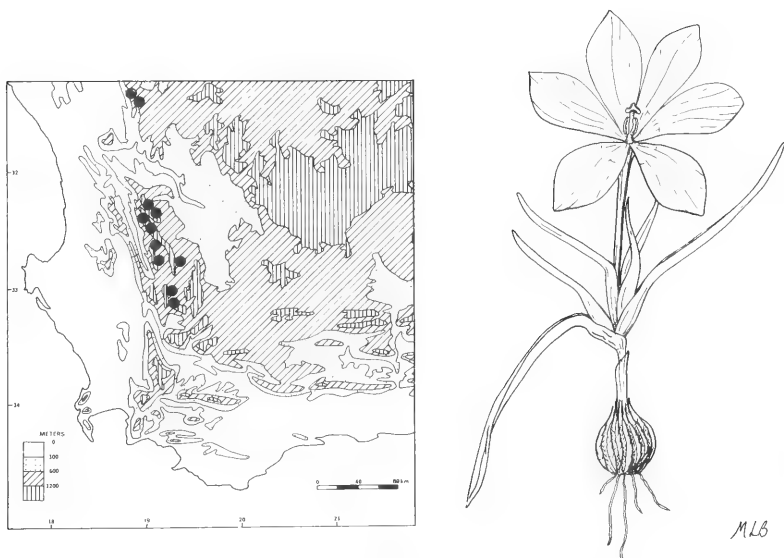


FIG. 6.
Distribution and morphology of *Galaxia citrina* (life size).

Flowering time: (July-) August-September (-October); flowers opening after 11h00, fading 16h30.

Distribution: moist shallow sandy soil overlying sandstone rock, mainly in the Cold Bokkeveld but extending from Ceres and Gydo Pass to Nieuwoudtville (Fig. 6).

Galaxia citrina is predominantly a montane species with its main range in the Cedarberg and northern Cold Bokkeveld above 700 m and up to 2 000 m. It extends north with isolated populations near Nieuwoudtville, and south occurring around Gydo Pass. Typically it grows in shallow, moist sandy soil overlying sandstone rocks, often in wet seeps. It is closely related to *G. variabilis* and when dry, larger-flowered forms can be distinguished only with difficulty. Vegetatively the two species are almost identical, but *G. citrina* always has yellow flowers, and relatively narrower tepals so that when fully open, gaps can be seen between them, a distinction emphasized by Lewis (1938). In contrast, *G. variabilis* usually has purple flowers with a yellow throat, and the tepals are usually broad and overlapping one another in the open flower. Over the main part of its range *G. citrina* has fairly small flowers, tepals 18–22 mm long. Plants from Nieuwoudtville, and from the type area near Gydo Pass have larger flowers, with tepals 23–28 mm long, a size more typical of *G. variabilis*, but these plants have tepals no more than 11 mm wide while *G. variabilis* usually has wider tepals.

Galaxia citrina has a diploid number of $2n = 16$ over part of its range, but is aneuploid with $2n = 14$ in plants from near the type locality, and polyploid with $2n = 34$ in a population from Rosendal in the eastern Cold Bokkeveld. As discussed under *G. variabilis*, the previous species, putative hybrids occur in several sites between *G. citrina* and *G. variabilis*.

CAPE—3119 (Calvinia): top of Van Rhyns Pass, W. of Nieuwoudtville (-AC), Marloth 12933 (PRE), Plowes 3230 (PRE), Lewis 5895 (NBG), Goldblatt 2470 (E, MO, PRE, WAG); hills W. of Nieuwoudtville, Goldblatt 3692 (MO), Barker 6471 (NBG, PRE).

—3219 (Wuppertal): Cedarberg, Sneeuwberg (-AC), Esterhuysen 13037 (BOL); Cedarberg Tafelberg, Esterhuysen 8104 (BOL); Bushmans Cave, Barnes s.n. (BOL 19444); Sneeuwkop, Cedarberg, Bodkin s.n. (BOL); Elandskloof (-CA), Barker 3124, 3799 (NBG), Leighton 1271 (BOL, K); 33 km E. Citrusdal in Cold Bokkeveld, Goldblatt 4024 (MO); Waboomsrivier (-CC), Hanekom 634 (PRE), 677 (K), Lewis 1411 (SAM); 40 km E. Citrusdal (-CD), Goldblatt 318 (BOL); Rosendal, Cold Bokkeveld, Goldblatt 4672 (MO).

—3319 (Worcester): top of Gydo Pass (-AB), Johnson 499 (NBG), Goldblatt 2588A (MO), Lewis 2633 (SAM); Gydo, Leipoldt 4078 (BOL); between Gydo and de Keur, Martin s.n. (BOL, NBG 59322, PRE).

2. SUBGENUS GALAXIA

Subgenus *Galaxia*

Type species: *Galaxia ovata* Thunb.

Leaves bifacial or unifacial distally, prostrate or erect. Flowers large to small, usually yellow, occasionally white. Stigmas irregularly fringed, radial margins often erect but minute.

Chromosome numbers: $2n = 18, 27, 36$.

Distribution: southern Cape to Namaqualand, centered in the western coastal belt from the Cape Peninsula to the Cedarberg.

5. *Galaxia grandiflora* Andr., Bot. Rep. tab. 164. 1801. Type: illustration in Andr. Bot. Rep., grown in England and probably collected by Niven in the Kamiesberg.

Plants solitary. *Corms* brown, with cancellate to fibrous tunics. *Leaves* entirely bifacial, oblong—obtusate to 30 mm long, ascending, shallowly channelled, margins hyaline, ciliate. *Flowers* clear yellow; *perianth tube* 15–25 mm long; *tepals* 22–30 mm, ovate, 11–15 mm at widest point, obtuse—obtuse-apiculate. *Filaments* 6 mm long, entirely united; *anthers* 4–5 mm. *Style* extending about 4 mm above anthers, branches short, stigmas irregularly fringed with short erect radial margins.

Chromosome number: $2n = 18$.

Flowering time: early to mid September; flowers opening 11h00–12h00, fading 16h00.

Distribution: local in sandy soils in the Kamiesberg (Fig. 7).

Though collected at several sites in the upper Kamiesberg *Galaxia grandiflora* is nowhere common. The plants from which the type illustration was made were part of George Hibbert's collection and they were almost certainly gathered by James Niven, the botanist employed by Hibbert to collect plants at the Cape for his private collection. Niven is known to have visited the Kamiesberg (Rourke, pers. comm.) most likely in 1800 when he collected *Leucospermum alpinum* and probably the first plants of *Moraea longiflora* (Goldblatt, 1976b).

Galaxia grandiflora was overlooked in botanical literature from the later nineteenth century until now, the type figure probably mistaken for *G. ovata*, which though similar has prostrate leaves. The flower is identical in both species, but those of *G. grandiflora* are considerably larger. The leaves also differ, for those of *G. ovata* are small, generally ovate, and the lower ones prostrate, while those of *G. grandiflora* are not only larger, but are channelled, and somewhat falcate as is clearly shown in the type figure. Despite its size, *G. grandiflora* is a diploid species, while most populations of *G. ovata* are tetraploid.

The rediscovery of living plants of *Galaxia grandiflora* was made by E. G. Oliver, who collected and grew a few specimens of this unusual *Galaxia* he found in the Kamiesberg. When first shown the cultivated plants I believed them to be a new species, but subsequent study has shown that they are identical to the long ignored *G. grandiflora*.

CAPE—3018 (Kamiesberg): E. slopes of Rooiberg, near Welcome, 1 100 m (-AC), Goldblatt 4049 (K, MO, NBG, PRE, S); Leliefontein, heights at foot of Ezelskop, Drège 1839 (S); between Leliefontein and Ezelskop, Drège s.n. (K); sandy places in Khomsoap Ravine; Pearson 6547 (BOL, K, PRE).

6. *Galaxia ciliata* Persoon, Synopsis 1: 41. 1805. Type: illustration in Andrews' Bot. Rep. tab. 94. 1800.

Plants solitary or in small clumps. *Corm* tunics brown, cancellate becoming finely fibrous, usually accumulating to form a thick mass round the corm. *Leaves* entirely bifacial, ascending and slightly recurved, channelled, often lightly undulate, oblong, obtuse; margins thickened and hyaline, densely ciliate-villous. *Flowers* yellow, campanulate; perianth tube 4.5–10 mm; tepals 14–16 mm long, ovate, obtuse, 8–9 mm at widest point. *Filaments* entirely united, 3.5–4 mm long; *anthers* divergent, 2.5–3.5 mm long, almost reaching to stigmas. *Stigma* irregularly fringed.

Chromosome number: $2n = 18$.

Flowering time: June–July (-early August).

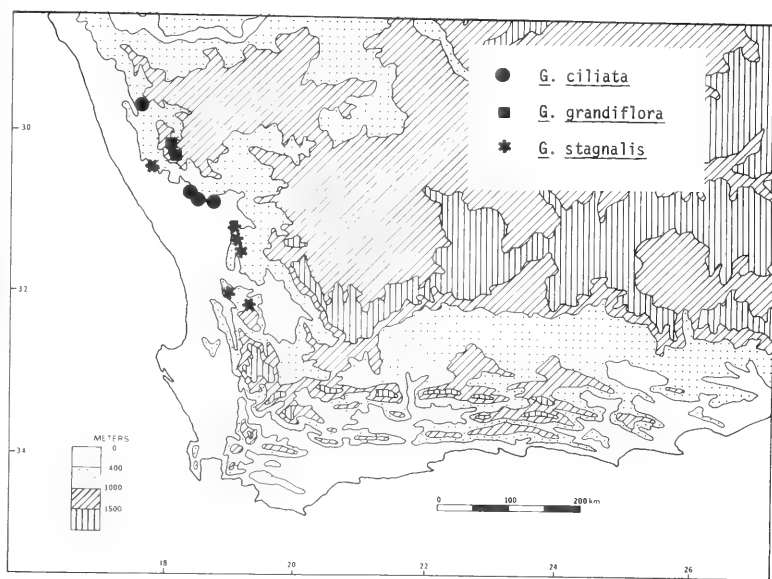


FIG. 7.
Distribution of *Galaxia grandiflora*, *G. ciliata*, and *G. stagnalis*.

Distribution: very local on clay slopes in Namaqualand, and recorded from the Nuwerus area in the south and from Spektakel Pass west of Springbok. (Fig. 7).

Galaxia ciliata is a rare species known only from a few sites in Namaqualand where it has been recorded only on clay soils which are very localised in this region of predominantly granitic rocks. It is rather inconspicuous, with small pale yellow flowers and appears to bloom irregularly from season to season, in dry years only producing very small leaves.

The species was first referred to *Galaxia ovata* when it appeared in Andrews' *Botanical Repository* and was only later recognised as distinct by Persoon in 1805. *Galaxia ciliata* is easily distinguished by its short, broad, channelled leaves with conspicuous long marginal hairs or cilia. The species is diploid, $2n = 18$, and seems related to the very much larger-flowered *G. grandiflora* from the Kamiesberg, and to the ovate, prostrate leafed *G. ovata*, widespread in the southwestern Cape.

CAPE—2917 (Springbok): clay slopes on E. approach to Spektakel Pass (-CC), Goldblatt 2357 (K, MO, NBG, PRE, WAG).

—3118 (Van Rhynsdorp): Bitterfontein (-AA), Salter 929 (K); Kareebergen (-AB), Schlechter 8218 (B, BOL, K, MO, PH, PRE, S); clay flats near Nuwerus, Goldblatt 3640 (K, MO, PRE, S).

7. *Galaxia luteo-alba* Goldbl., sp. nov.

Tunicae cormi atrobrunneae, fibrosae. Folia bifacialia ovato-oblonga, inferiora prostrata, 20–30(–40) mm longa, marginibus perciliatis. Flores lutei in centro, albescens ad margines tepalarum; tubus perianthii 7–16 mm longus; tepala ovata, obtusa 15–21 mm longa, 7–10 mm lata. Filamenta 5–7,5 mm longa, connata prope basin, divergentia; anthera 2–3 mm longa. Stylus gracilis, erectus, deflexens, antheras excedens; stigmata fimbriata.

Type: SOUTH AFRICA, Cape, Pakhuis Pass, Cedarberg, Goldblatt 2205 (MO, holotype; K, NBG, PRE, S, isotypes). Fig. 8.

Plants usually solitary or in small clumps. *Corm* tunics dark brown, matted and fibrous. *Leaves* bifacial, ovate-oblong, lower prostrate 20–30(–40) mm long, usually obtuse, up to 5 mm wide; margins with hyaline border prominently ciliate; cilia 2–3 times the width of border. *Flowers* deep yellow in the throat, fading to cream at tips of tepals; *perianth tube* 7–16 mm long; *tepals* ovate, obtuse 15–21 mm long, 7–10 mm at widest point. *Filaments* 5–7,5 mm long, free in upper two thirds, spreading; anthers 2–3 mm long. *Style* slender, extending 10 mm from throat of perianth tube, initially erect, and much exceeding the anthers, becoming declinate; branches short, stigmas fringed, radial margins erect, short.

Chromosome number: $2n = 18, 27$.

Flowering time: July–August; flowers opening about 11h00, closing 16h00–16h30.

Distribution: moist shallow sandy soil on rock shelves in the Cedarberg, and north near Nieuwoudtville (Fig. 8).

Galaxia luteo-alba is distinctive in being the only member of the genus with filaments free almost to the base. When the buds first open the stamens are erect, and held close together round the style, but later when the flowers are fully open the stamens separate and spread outwards while the style bends to one side. The flower colour is also distinctive, deep yellow in the throat, becoming lighter gradually towards the edge of the tepals so that the tips are cream-white. This colouration is unique for subgenus *Galaxia*, but is also found in some hybrids of *G. citrina* \times *G. variabilis* (subgenus *Eurystigma*).

It is easy to recognise live flowering material of *Galaxia luteo-alba* from the characteristic colour, and the free stamens. Problems do arise with poorly dried specimens but leaf shape should serve to distinguish *Galaxia luteo-alba* from all species except *G. ovata*, and in this case the ciliation of the leaf margins is usually

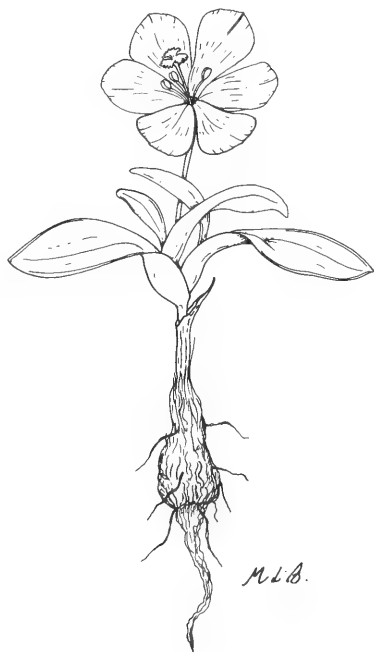
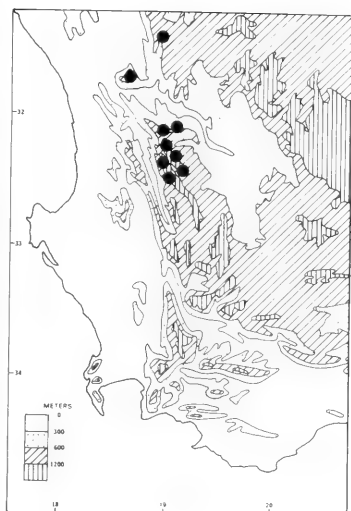


FIG. 8.
Distribution and morphology of *Galaxia luteo-alba* (approx. life size).

reliable. Cilia are much longer in *G. luteo-alba*, up to three times the width of the hyaline leaf border, and visible to the naked eye. In *G. ovata* the cilia are shorter, seldom even twice the width of the leaf border, and in many forms of this species, though not the northern populations, the cilia are scattered all over the leaf border instead of in the usual single row.

I have found *Galaxia luteo-alba* to be very common in the Cedarberg, where it extends from the Stadsaal Rocks near Matjiesrivier to Pakhuis Pass and Brandewyn River. There is also a collection from south of Nieuwoudtville, (*Leipoldt* 3838) which needs confirmation, for this area is well-collected and the species has not been recorded by others. *Galaxia luteo-alba* always occurs in wet habitats, in shallow sandy soil overlying sandstone rock. Altitude seems unimportant with plants found from 500–1 400 m.

There are three other species of *Galaxia* in the Cedarberg, two of which may grow near *G. luteo-alba*. The tetraploid *G. ovata* occurs in close proximity to *G. luteo-alba* in many places but tends to occupy drier sites with deeper, better

drained soil. *Galaxia stagnalis* is virtually sympatric with *G. luteo-alba* north of Pakhuis Pass. *Galaxia stagnalis* usually occurs half-submerged and in water-logged soil, and blooms earlier in this area than *G. luteo-alba*, which only flowers when the soil begins to dry. *Galaxia citrina* is found mainly at higher elevations and I have not seen it growing near *G. luteo-alba*.

CAPE—3118 (Van Rhynsdorp): Giftberg (-D), *Phillips 7564* (SAM); Nardouwsberg (-DC), *Stokoe s.n.* (SAM 60187).

—3119 (Calvinia): between Nieuwoudtville and Oorlogskloof (-CC), *Leipoldt 3838* (BOL).

—3219 (Wuppertal): Top of Pakhuis Pass (-AA), *L. Bolus s.n.* (BOL 31112), *Goldblatt 568* (BOL); Pakhuis Pass near Leipoldt's Grave, *Goldblatt 2205* (K, MO, NBG, PRE, S), *Nordenstam & Lundgren 1330* (MO, S); Heuningvlei, *Esterhuysen 8066* (BOL), *Stokoe s.n.* (SAM 55677); between Pakhuis and Brandewyn River, *Goldblatt 3881* (MO, NBG); Cedarberg, Middelberg (-AC), *Kerfoot 5968* (NBG); near Middelberg hut, *Barnes s.n.* (BOL 19445); Wolfberg, *Esterhuysen 20569A* (BOL); southern Cedarberg at Krom River turnoff (-CB), *Goldblatt 3872* (K, MO, PRE, WAG); Stadsaal Rocks, *Goldblatt 3877* (K, MO, PRE, WAG).

8. *Galaxia ovata* Thunb., Gen. Pl. Nov.: 50. 1782, excl. var β corollis violaceis. Type: SOUTH AFRICA, Cape, around Cape Town, *Thunberg s.n.* (Herb. Thunb. 15450, UPS, lectotype, C, S, isotypes.) **Fig. 9.**

Ixia galaxia L.f., Suppl.: 93. 1781. Type: SOUTH AFRICA, Cape, Cape Peninsula, *Sparrman s.n.* (S. lectotype).

Plants solitary or often forming small cushion-like tufts. *Corm* tunics brown, reticulate often with prominent vertical ridges. *Leaves* bifacial, ovate, obtuse, apiculate, outermost leaves prostrate, 20–30 mm long; margin border thickened, hyaline, minutely ciliate; cilia either uniseriate or scattered over entire border. *Flowers* yellow, campanulate; *perianth tube* 5–20 mm long; *tepals* 16–20 mm long, ovate, 8 mm wide, obtuse. *Filaments* entirely united, 4–5 mm long, *anthers* 2–3 mm long, erect. *Style* erect, extending well above anthers; *stigmas* fringed.

Chromosome number: $2n = 18, 36$.

Flowering time: July–August–mid September in the southern Cape; flowers opening 10h30 closing 16h00.

Distribution: southwestern Cape, from Elim in the east to the Cedarberg in the north; most frequently in sandy soil (Fig. 9).

Galaxia ovata is common throughout its range from Elim in the southern Cape to the Cedarberg in the north. Its characteristic feature is its small prostrate leaves. Plants in the southeast of its range are diploid, $2n = 18$, usually solitary, and occur on heavy clay soils. Elsewhere *G. ovata* is tetraploid, $2n = 36$, forms large

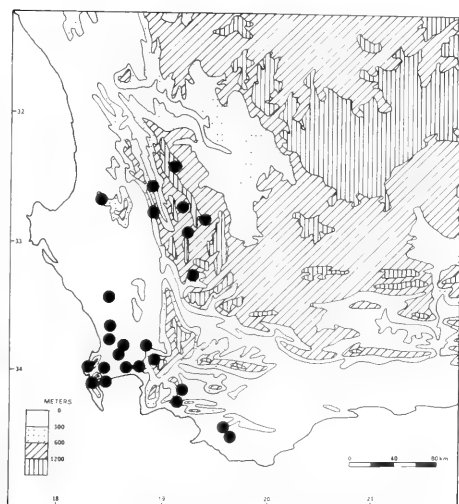


FIG. 9.
Distribution and morphology of *Galaxia ovata* (approx. life size).

clumps and grows mainly in sandy soils. In the south it grows at low to mid altitudes, while to the north it occurs above 1 000 m. Many populations have a very distinctive border to the leaf margin, which is covered by many tiny cilia. In the southeast and in the north however, marginal cilia are restricted to a single row.

This species occurs together with or close to *Galaxia fugacissima* in many localities, amongst *G. alata* in at least one place, and close to *G. luteo-alba* in the Cedarberg. Hybrids are not known, but I have occasionally seen plants with leaves intermediate between the narrow ones of *G. fugacissima* and the broad ones of *G. ovata*. To date I have not been able to grow any of these plants to examine their cytology which would confirm hybridity since the presumed parents are diploid and tetraploid.

Galaxia ovata is selected as the type species of *Galaxia* as it was the first of the two species assigned to the genus by Thunberg when he described the genus. Thunberg's concept of this species included *G. ovata* as here circumscribed, and *G. versicolor*. He distinguished these as var. α *corollis totis flavis* (the more

common) and var β *corollis violaceis*. In selecting the yellow-flowered plant as the type for *G. ovata*, *G. versicolor* is now excluded entirely from *G. ovata*.

CAPE—3218 (Clanwilliam): slopes above Aurora, Piketberg distr. (-BB), *Lewis* 5945 (NBG); north side of Grays Pass (-DB), *Leipoldt* s.n. (K).

—3219 (Wuppertal): Cedarberg, Driehoek road (-AC), *Goldblatt* 3878 (K, MO, NBG, PRE, S); between de Keur and Elandskloof Mission (-CD), *Martin* s.n. (NBG 59296), *Compton et al.* s.n. (NBG 59255); between Twee Rivieren and Leeu R., *Goldblatt* 2575 (MO); Bo-Bokfontein, *Nordenstam & Lundgren* 1271 (MO, S).

—3318 (Cape Town): Clifton, Cape Town (-CD), *Barker* 1877 (NBG); near Rondebosch, *H. Bolus* 4577 (BOL); Koeberg, 40 km S. Malmesbury (-DA), *Goldblatt* 2174 (MO, WAG); 20 km S. Malmesbury, *Goldblatt* 2177 (MO, NBG); Tygerberg (-DC), *Burchell* 971 (K); Peaslake, Durbanville, *Taylor* 4951 (NBG, PRE).

—3319 (Worcester): flats near Prince Alfreds Hamlet (-AD), *Oliver* 4972 (MO, STE), *Goldblatt* 2230 (MO, WAG); lower slopes Gydo Pass, *Acocks* 282 (S); between Salt R. and Kalabaskraal (-DA), *Hutchinson* 160 (K, PRE); Jonkershoek (-DD), *Garside* 612 (K); Stellenbosch flats, *Garside* 1075 (K); Duthie Reserve, Stellenbosch, *Bos* 243 (PRE).

—3418 (Simonstown): Llandudno (-AB), *Compton* 8889 (NBG), *Goldblatt* s.n. (BOL); lower slopes of Constantiaberg, *Schlechter* 988 (PRE); Faure (-BB), *Strey* 554 (PRE); Somerset West, *Parker* 3813 (K); between Somerset West and Strand, *Bos* 293 (PRE).

—3419 (Caledon); Nuwedam, between Elim and Stanford (-DA), *Goldblatt* 2609 (MO).

9. *Galaxia stagnalis* Goldbl., sp. nov.

Planta solitaria. Tunici cormi fibrosi, saepe unguibus prominentibus. Folia bifacialia, linearia vel lanceolata, acuta, raro obtusa, marginis raro pauci-ciliatis. Flores lutei; tubus perianthii 5–10 mm longus; tepala 10–15 mm longa, ovata, 5–8 mm lata, obtusa. Filamenta connata ad apice vel libera in parte superiore, 4,5–5 mm longa; anthera 1,5–2,0 mm. Stylus antheras non excedens; stigma fimbriata, recurva, antheras contigua.

Type: SOUTH AFRICA, Cape, pools at the top of Van Rhyns Pass, *Goldblatt* 3888 (MO, holotype; K, NBG, PRE, S, isotypes).

Plants solitary. *Corm* tunics of fine matted fibres or with prominent vertical claws. *Leaves* bifacial, straight, erect or prostrate, linear or lanceolate, acute, occasionally obtuse, margin border usually smooth, rarely with minute scattered cilia. *Flowers* yellow, campanulate; *perianth tube* 5–10 mm long; *tepals* 10–15

mm long, 5–8 mm wide, ovate, obtuse. *Filaments* 4.5–5.0 mm, entirely united, or free in upper third; *anthers* 1.5–2.0 mm, diverging. *Style* dividing at level of anthers, stigmas fringed, recurved and touching anthers.

Chromosome number: $2n = 36$.

Flowering time: June - early August; flowers open about 11h30, fade about 16h00.

Distribution: seasonal pools, wet seeps, streams, with roots and corms submerged, in the northern Cedarberg, Nardouw Mountains and Nieuwoudtville escarpment, and locally in Namaqualand (Fig. 7).

Galaxia stagnalis is a rather variable complex comprising small-flowered plants of the northern Cedarberg, Nardouw mountains and Nieuwoudtville escarpment. A collection from Garies in Namaqualand, *Lewis s.n.*, also appears to belong in this species, though this is rather far from the main range of *G. stagnalis*. All populations that I have seen grow partly submerged in water, either in temporary pools or in the course of small seasonal streams, and plants flower very early in the season, usually in June or July, blooming as the water level drops below the buds. Flowers are very small, with a short perianth tube. In most populations the anthers are shortly stalked, and the rather broad, fringed stigmas recurve to come in contact with the pollen. Plants grown from four separate populations have all proved polyploid, $2n = 36$, and are self-compatible and autogamous in cultivation, an unusual feature for Iridaceae, and *Galaxia*, but also known for *G. albiflora*, and some very small-flowered forms of *G. fugacissima*.

Galaxia stagnalis appears related to *G. ovata*, many populations of which are also tetraploid, but it has narrower leaves which are seldom truly ovate and prostrate. It is probably no more closely related to *G. ovata* than to other broad-leafed species of subgenus *Galaxia*, such as *G. ciliata*, and *G. luteo-alba*. Good taxonomic characters are lacking in most species of the subgenus so that little more can be said about its relationships. *Galaxia stagnalis* can be recognized from its habitat, early blooming, small flowers, often stalked anthers and short style. Leaf border is often distinctive, usually lacking entirely the marginal cilia found in all related species.

CAPE—3017 (Hondeklipbaai): Garies (-DB), *Lewis s.n.* (BOL).

—3118 (Van Rhynsdorp): Nardouw Mts above Doorn R., (-DC), *Goldblatt 2191* (MO, NBG).

—3119 (Calvinia): top of Van Rhyns Pass (-AC), *Goldblatt 2468* (BOL, MO, WAG), *Goldblatt 3888* (K, MO, NBG, PRE, S), *Hall 2479* (NBG); Lokenberg, *Acocks 18229* (PRE); 7 km N.W. of Nieuwoudtville, rock seep, *Goldblatt 3958* (MO).

—3219 (Wuppertal): Brandewyn River, seasonal stream bed (-AA), *Goldblatt 2203* (MO, WAG); between Pakhuis and Brandwyn R., *Goldblatt 3883* (MO).

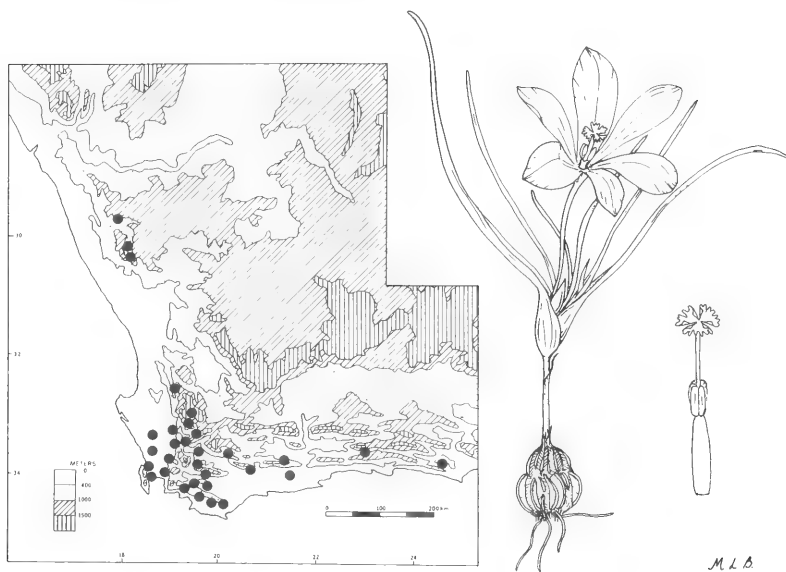


FIG. 10.

Distribution and morphology of *Galaxia fugacissima* (life size) with stamens and stigmas enlarged.

10. *Galaxia fugacissima* (L.f.) Druce, Rep. Bot. Exch. Club. Br. Is. 1916: 624, 1917. Fig. 10.

Ixia fugacissima L.f., Suppl.: 94. 1781. Type: South Africa, Cape, Cape Town, Thunberg s.n. (Herb. Thunb. 15449, UPS, lectotype)

Galaxia graminea Thunb., Nov. Gen.: 50. 1782. Type: South Africa, Cape, Cape Town, Thunberg s.n. (Herb. Thunb. 15449, UPS, holotype); nom illeg., superfl.

Galaxia graminifolia Harv., orth. var pro *G. graminea* Thunb.

Plants solitary or forming thick clumps. *Corm* tunics brown, fibrous, occasionally with conspicuous vertical ribs. *Leaves* 30–80 mm long, linear, bifacial and channelled, either with a short acute unifacial apex or unifacial in upper half, \pm erect, spreading or falcate; margins of bifacial portion with a hyaline border, smooth or minutely ciliate. *Flowers* pale yellow, sweet scented; *perianth tube* 10–24 mm long; *tepals* (11–)15–19 mm long, ovate, obtuse, 4–9 mm at widest point. *Filaments* usually entirely united, (3–)5–6 mm long occasionally free in upper third; *anthers* 1.5–4 mm, diverging. *Style* usually reaching beyond anthers, occasionally not exceeding anthers; *style branches* short, stigmas fringed.

Chromosome number: $2n = 18, 36$.

Flowering time: July to mid September; flowers open 10h30–11h00, fading 16h00.

Distribution: widespread in the southern and southwestern Cape and extending locally in Namaqualand to Springbok; usually on seasonally waterlogged sandy soils, smaller forms occur on clay in the southern Cape (Fig. 10).

Galaxia fugacissima is distinctive in *Galaxia*, being the only species with linear, grass-like leaves. In most forms the leaves are unifacial distally and quite straight. In the northern forms from Namaqualand which I have assigned to this species, the leaves are strongly falcate, but still very narrow while in the south, from Caledon eastwards, and especially in drier sites, the leaves tend to be somewhat broader and spreading, and sometimes grooved and bifacial almost to the apex.

In flower structure there is nothing to distinguish *Galaxia fugacissima* from most other species of subgenus *Galaxia* but all forms of the species that I have seen live have a strong sweet scent, a character not noted in other species. Plants east of the Hottentots Holland Mountains usually have smaller flowers, and often grow on clay, rather than the typical wet sand habitat. Some of these small-flowered forms from near Caledon, at Drayton and Middleton, exhibit variation in style length, with many plants having a short style so that the stigmas are in contact with the anthers. These plants are autogamous, while other populations studied are strongly self-incompatible. Though the small-flowered and self-compatible, autogamous populations would seem to merit taxonomic recognition at least at subspecific level, it is in practice often quite impossible to recognize them from herbarium material and I have therefore avoided this issue.

West and north of the Hottentots Holland *Galaxia fugacissima* grows in damp sites, usually on sandy flats that are very wet in the winter. It is sympatric with *G. albiflora* on Rondebosch common, where hybrids occur. These hybrids are discussed in detail under *G. albiflora*. *Galaxia fugacissima* also grows with *G. versicolor* at some sites, and in other places with *G. ovata* and in the latter situations I have seen some broader-leaved plants which may be hybrids.

Galaxia fugacissima is believed to have been collected first by Thunberg, who found it to be plentiful on the Cape Peninsula. No doubt it was this species flowering in profusion like the massed stars of a galaxy which suggested to Thunberg the generic name *Galaxia*. Although the younger Linnaeus described this species, assigning it to *Ixia*, Thunberg's later specific epithet "graminea" was widely used until well into the twentieth century when Druce drew attention to the existence of the earlier name for the species.

CAPE—2917 (Springbok): 30 km S. Springbok (-DD), Compton 20729 (NBG).

- 3018 (Kamiesberg): Leliefontein (-AC), *Goldblatt* 2408 (E, MO, PRE, S); top of Studers Pass, *Goldblatt* 3972 (K, MO, NBG).
- 3219 (Wuppertal): Citrusdal Vlei (-CA), *Compton* 17431 (NBG, PRE), *Goldblatt* 2232 (E, MO, PRE, S); 10 m N. of Citrusdal, *Lewis* 1034 (SAM); Leeu R., Cold Bokkeveld (-CC), *Barker* 3803 (NBG, PRE).
- 3318 (Cape Town): near Cape Town (-CD), *Thunberg s.n.* (UPS), *MacOwan* in Herb Norm. Aust. Afr. 1539 (BR, K, SAM, UPS), *H. Bolus s.n.* (BOL 4806, K); Rondebosch Common, *Isaac s.n.* (BOL), *Goldblatt* 321 (BOL), *Lewis* 671 (SAM); Gardens, Cape Town, *Burchell* 8396 (K); Camps Bay, *Ecklon* 330 (BOL, K, MO); Wellington (-DB), *Kies* 102 (PRE); Durbanville (-DC), *Taylor* 5004 (K, PRE); Stellenbosch flats (-DD), *Garside* 1020 (K), *Worsdell s.n.* (K).
- 3319 (Worcester): Agterwitzenberg Vlake (-AB), *Goldblatt* 2589 (MO, WAG); between Bains Kloof and Wolseley (-CA), *Goldblatt* 2430 (BOL); Bothas Halt, *Compton* 18275 (NBG, PRE); near Worcester (-CB), *Steyn* 199 (BOL, PRE); Ceres, *Rogers* 28735 (SAM).
- 3320 (Montagu): near Baths at Montagu (-CC), *Page s.n.* (BOL 15625).
- 3321 (Ladismith): Muiskraal vlei (-CC), *Galpin* 4654 (GRA, K, PRE).
- 3323 (Willowmore): headwaters of Wagenbooms R. (-D), *Fourcade* 2673 (K).
- 3418 (Simonstown): Wynberg Hill (-AB), *Schlechter* 1577 (GRA).
- 3419 (Caledon): foot of Viljoens Pass (-AA), *Goldblatt* 2490A (MO); Middleton, E. Caledon (-AB), *Goldblatt* 2631 (MO, NBG, PRE); Hermanus (AC), *Salter* 1192 (K); Kleinrivier Mts (-AD), *Zeyher* 4065 (K, SAM); Drayton siding, E. Caledon (-BA), *Goldblatt* 2515 (K, MO, S); Elim (-DA), *Frowein* 1087 (PRE).
- 3420 (Bredasdorp): near Swellendam (-AB), *F. Bolus s.n.* (BOL 23384); The Poort, Bredasdorp (-CA), *Compton* 14802 (NBG); near Bredasdorp, *Morris* 274 (BOL, NBG).
- 3421 (Riversdale): hills near Riversdale (-AB), *Muir* 2574 (BOL, PRE).
- 3424 (Humansdorp): Humansdorp (-BB), *Fourcade* 2316 (BOL).

11. *Galaxia alata* Goldbl., sp. nov.

Tunicae cormi pallidae, medullosae, prominentibus alis. Folia bifacialia infra, marginibus ciliatis, teretia supra, \pm succulenta, falcata vel \pm erecta, 15–30(–60) mm longa. Flores albi vel flavi; tubus perianthii 5–20 mm longus; tepala 1,3–1,9 cm ovata, obtusa. Filamenta 4–5 mm longa, connata; antherae 2,0–2,5 mm longae. Stylus antheras excedens, rami breves, stigmata fimbriata.

Type: SOUTH AFRICA, Cape, roadside 20 km S. of Malmesbury at Klein Dassenberg intersection, *Goldblatt* 2176 (MO, holotype; K, NBG, PRE, S, isotypes). **Fig. 11.**

Plants usually solitary, small, 20–40 mm tall. *Corm* tunics pale, entire, composed of pith-like material, with several conspicuous vertical wings. *Leaves*

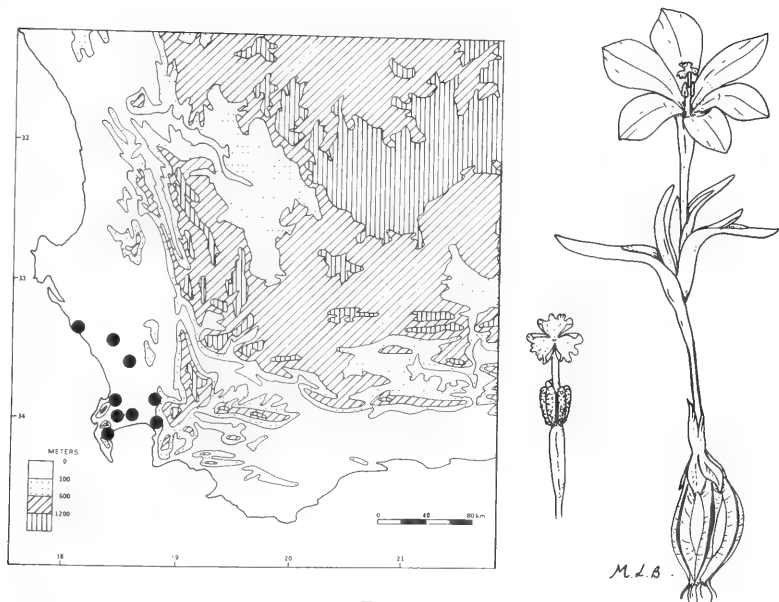


FIG. 11.

Distribution and morphology of *Galaxia alata* (approx. life size) with stamens and stigmas enlarged.

bifacial below, distally terete, somewhat succulent, outspread to falcate, 15–30(–60) mm long, bifacial portion with hyaline, minutely ciliate margin. *Flowers* white or yellow; *perianth tube* 5–20 mm long; *tepals* 13–19 mm long, ovate, obtuse, 6.5–8.0 mm wide. *Filaments* entirely united, 4–5 mm long; *anthers* sessile, 2.0–2.5 mm long diverging from base. *Style* extending \pm 4 mm above anthers, branches short; *stigmas* irregularly fringed.

Chromosome number: $2n = 18, 27$.

Flowering time: July–August; flowers open ca. 12h00 and fade ca. 15h30.

Distribution: moist, usually sandy situations, on the flats between Cape Town, Malmesbury and the Hottentots Holland Mountains (Fig. 11).

Galaxia alata is apparently a very rare species of the flats between the Hottentots Holland Mountains and the west coast between Cape Town and Darling. Except when in flower it is inconspicuous, with its tiny leaves barely noticeable in the surrounding vegetation. The flower is typical of subgenus *Galaxia* in size and structure, but vegetatively this species is most distinctive. Its corms are remarkable, being unique in the genus with tunics consisting of an

entire layer of bony material which has several prominent vertical wings. The leaves are also unusual in being terete in the upper half and slightly succulent. Both the leaves and corms of this species are unmistakable.

I have seen only two live populations, one south of Malmesbury, where yellow and white flowered plants occur, and one near Mamre Road, where all individuals have yellow flowers. South of Malmesbury most plants are diploid, $2n = 18$, with an occasional triploid, $2n = 27$, perhaps cryptic hybrids with *G. ovata* ($2n = 36$) which grows at the same site. All plants examined from the Mamre Road locality are triploid and do not reproduce by seed, but by cormlets produced at the base of the sterile ovaries.

CAPE—3318 (Cape Town): Ysterfontein (-AC), *Barker* 3845 (NBG); near Mamre Road Station (-BC), *Goldblatt* 3825 (K, MO, NBG); Claremont (-CD), *H. Bolus* 3759 (BOL, K); Salt River, sandy flats, *Marloth* 161 (PRE); racecourse at Kenilworth, *H. Bolus* s.n. (BOL 1892); 20 km S. Malmesbury (-DA), *Goldblatt* 617 (BOL), 2176 (K, MO, NBG, K, S), 2231 (C, E, MO, WAG); near Stellenbosch (-DD), *Guthrie* s.n. (BOL 18572).

—3418 (Simonstown): Kalk Bay Mt, above the Fishery (-AB), *F. Bolus* s.n. (BOL 13713); Bergvliet farm, *Purchell* s.n. (SAM); Isoetes Vlei (-BA), *Rowe* 25 (NBG); Somerset West (-BB), *Parker* 4214 (BOL, K, NBG).

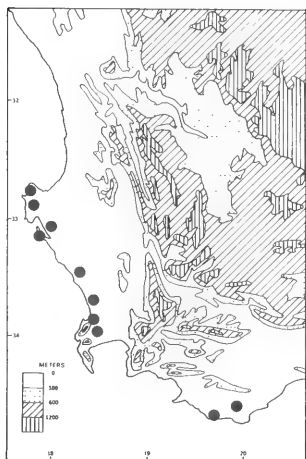


FIG. 12.
Distribution and morphology of *Galaxia albiflora* (life size) with stamens and stigmas enlarged.

12. *Galaxia albiflora* Lewis, Jl S. Afr. Bot. 7: 44. 1941. Type: South Africa, Cape, Rondebosch Common, *Lewis s.n.* (SAM 54289). **Fig. 12.**

Plants solitary. *Corm* tunics dark brown with vertical ribs usually prominent, and woody. *Leaves* 30–60 mm long, linear, bifacial, channelled, to 6 mm wide, acute to obtuse, margins with sparsely ciliate hyaline border. *Flowers* small, white with yellow throat; *perianth tube* 10–13 mm long; *tepals* 9–12 mm long, ovate, obtuse, ca. 4 mm at widest point. *Filaments* united, ca. 4 mm long; *anthers* ca. 1.5 mm long appressed to style and stigmas. *Style* dividing near base of anthers; *stigmas* fringed, becoming irregular, borne below apex of anthers.

Chromosome number: $2n = 18$.

Flowering time: July–September; flowers open 13h00, fade 15h30.

Distribution: local near the coast between Cape Agulhas and Saldanha Bay, usually in seasonally wet, sandy situations, often in shallow soil on rock outcrops (Fig. 12).

Galaxia albiflora is very inconspicuous even when in flower, and though little collected, it is probably fairly common throughout its range. It occurs only in seasonally wet situations along the coast from near Cape Agulhas to Saldanha Bay, and only in sandy soils. It is specialised in its reduced flower and very brief flowering time, 13h00 to 15h30. It is also autogamous, with pollen being shed directly on the stigmas. It thus appears as the end of a line of evolution which has resulted in morphological reduction and autogamy.

In the wild *Galaxia albiflora* is visited occasionally by small bees, and does hybridize with *G. fugacissima*, the only species that I have seen growing near it. Hybrids have been found only at Rondebosch Common, Cape Town, and are fairly numerous. This site is ecologically disturbed, with *G. albiflora* local in wetter sites and *G. fugacissima* mainly along trampled pathways and in open places, where it occurs in masses. The hybrid occurs mainly in open situations and is intermediate between the parental species in flower size, colour and leaf shape. Though pollen staining indicates barely reduced pollen viability, and both parents are diploid with $2n = 18$, the hybrids are completely sterile, and reproduce only vegetatively by producing cormlets. Reasons for the sterility are unknown.

It seems likely that *Galaxia albiflora* is of recent origin and perhaps evolved after the last interglacial, when sea level receded about 10 000 years ago. It occurs only near the coast, and generally between 10 and 30 m above sea level, though I have seen it on coastal hills up to 150 m high. Its autogamous reproduction would have enabled it to colonize newly available coastal habitats rapidly, as the sea retreated.

CAPE—3217 (Vredenburg): near Vredenburg (-DD), *Lewis 1140* (SAM), *Leighton 585* (BOL); Steenberg Cove, *Lewis 1049* (SAM).

—3318 (Cape Town): Langebaan (-AA), *Lewis s.n.* (BOL 20704); Olifants

Kop, Langebaan, *Goldblatt 2339* (MO, PRE, S, WAG); Posberg, Donkergat Peninsula, *Goldblatt s.n.* (MO); Rondebosch Common (-CD), *Isaac s.n.* (BOL), Barker 4641 (BOL, NBG), *Goldblatt 2436* (MO, S); Blouberg, *Pillans s.n.* (BOL 18564); flats at Salt River, *Marloth s.n.* (PRE).

—3419 (Caledon): Ratelrivier, flats near Die Dam (-DA), *Esterhuysen 32019A* (BOL), *Goldblatt 2603* (K, MO, NBG).

INADEQUATELY KNOWN SPECIES

Galaxia sp. 1

Three collections from French Hoek Forest Reserve, *Salter 6891* (30 Aug., near Bushmans Castle) and *Isaac s.n.* (3 Oct.) and a third, *Compton 13875* (from Berg River Hoek, 4 Oct.), may represent an undescribed species. Vegetatively, they resemble *Galaxia versicolor*, but have pale yellow flowers, with small dark dots at the base of the tepals. The filaments are free in the upper 1 mm, and the anthers 2 mm long. Stigma details are not visible clearly but they seem to be entire. Perfectly pressed flowers or live material are needed for further analysis.

Galaxia sp. 2

A single collection from the Montagu district, at Eendracht (*Lewis 4746*) is impossible to identify. The flowers appear to have been yellow, and have apparently sessile anthers. Unfortunately the stigmas cannot be properly seen, but possibly emerge between the anthers, if so unique in the genus. The most likely determination is *G. citrina*, its nearest station being at Gydo Pass, a considerable distance from Eendracht. Live material is needed before the identity of the Eendracht plants can be evaluated.

EXCLUDED SPECIES

Galaxia multiflora Spreng. Neue Entdeck. 1: 251. 1820.

The description is inadequate for identification of this species in the absence of a type or authentic specimen. The species is probably *G. ovata*.

G. ixiaeflora [DC in] Red. = *Ixia monadelphica* de la Roche.

G. magellanica Steud. = *Tapeinia pumila* (Forst.f.) Baill.

G. minuta Ker = *Pauridia minuta* (L.f.) Dur. & Schinz. (Hypoxidaceae).

G. narcissoides (Cav.) Willd = *Phaeophleps biflora* (Thunb.) R. C. Foster.

G. obscura Cav. = *Ona obscura* (Cav.) Ravenna.

G. pedunculata Beg. = *Moraea falcifolia* Klatt.

G. plicata Jacq. = *Lapeirousia plicata* (Jacq.) Diels.

G. ramosa [DC in] Red. = *Ixia monadelphica* de la Roche.

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CHARACTERIZATION OF PECTIN METHYLESTERASE FROM MARVEL TOMATOES

T. THERON and O. T. DE VILLIERS*

(Fruit and Fruit Technology Research Institute, Stellenbosch)

ABSTRACT

Pectin methylesterase isolated from Marvel tomatoes exhibited maximum activity at pH 7,5 in 0,15 M NaCl and 1 % citrus pectin and has a K_m of 0,1 % for citrus pectin. The enzyme revealed considerable heat-stability partly ascribed to the finding that it contains carbohydrate components consisting of arabinose, xylose, mannose, galactose and glucose. The presence of 18 kinds of amino acids was established in the enzyme.

UITTREKSEL

KARAKTERISERING VAN PEKTIENMETIELESTERASE UIT MARVEL TAMATIES

Pektiemetielesterase uit Marvel-tamaties het optimum aktiwiteit by pH 7,5 in 0,15 M NaCl en 1 % sitruspektien getoon en het 'n K_m -waarde van 0,1 %. Die ensiem het 'n hoë mate van hitte-stabiliteit getoon wat moontlik toegeskryf kan word aan die feit dat dit 'n koolhidraatgedeelte bevat. Gaschromatografiese-analises van die koolhidraatgedeelte het die teenwoordigheid van arabinose, xilose, mannose, galaktose en glukose aangetoon. Dit is ook vasgestel dat 18 soorte aminosure in die ensiem teenwoordig is.

INTRODUCTION

The isolation and purification of pectin methylesterase (PME) (E.C. 3.1.1.11.) from Marvel tomatoes has been described in a previous paper (Theron, De Villiers & Schmidt, 1977). The enzyme was extracted with NaCl and purification was achieved by means of ammonium sulphate fractionation and chromatography on various Sephadex G-types. It was shown that the purified enzyme had an apparent lack of a net charge and that the enzyme contained a carbohydrate residue. In the present paper more properties of the enzyme, as well as the chemical composition of the protein and carbohydrate residue of the enzyme, are described.

MATERIAL AND METHODS

Plant material

Mature fruits of tomatoes (*Lycopersicum esculentum*, cv. Marvel) were purchased from a local dealer and stored at -10°C until used.

*Address: Department of Biochemistry, University of Stellenbosch.

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Substrate

A commercial preparation of citrus pectin (100 grade, 24 % esterified) was used throughout the investigation. A 1 % solution in 0,15 M NaCl (pH 7,5) was prepared daily.

Isolation and purification

PME was isolated and purified as described previously (Theron, De Villiers & Schmidt, 1977).

Determination of PME activity

Determination of PME activity was carried out according to the method of MacDonnel, Jansen & Lineweaver (1945) by means of continuous titration of the carboxyl groups liberated during the course of the reaction.

Effect of enzyme concentration

To study the effect of PME concentration on the initial reaction velocity 20 cm³ of substrate was used. Enzyme activity was determined in 5, 10 and 15 cm³ of the enzyme solution (in 0,15 M NaCl) respectively. The volume and concentration of the substrate for each determination was adjusted to maintain a constant final concentration and volume.

Effect of substrate concentration

For the determination of the K_m -value of tomato PME the same assay procedure as described above was employed at pH 7,5 except that the citrus pectin concentration was varied. The enzyme concentrations used were chosen to effect a convenient change of pH per min. As the molecular mass of the substrate is not known, the K_m -value is presented as g/100 cm³ (%) according to Nakagawa, Yanagawa & Takehana (1970).

Effect of pH

The determination of activity at various pH values was carried out according to the method of Nakagawa, Yanagawa & Takehana (1970). The reaction was carried out at 30 °C for 10 min, recording alkali consumption every min.

Heat stability

To study the effect of temperature on the stability of PME, enzyme preparations were kept at the various temperatures in a water bath for exactly 5 min, immediately cooled to 30 °C and added to the substrate. PME activity was determined as described above.

Amino acid composition

Samples of purified PME were hydrolysed in sealed evacuated tubes with 1 cm³ 6 M HCl at 110 °C for 22 hours. After removal of the HCl by evaporation under reduced pressure, the residues were dissolved in citrate buffer at pH 2,2 and

the amino acid composition of the hydrolysates determined with a Beckman model 120 C automatic amino acid analyser.

Carbohydrate composition

For the determination of the carbohydrate composition of purified PME, the methods of Clamp, Dawson & Hough (1967) and Chambers, Bhatti & Clamp (1970) were used.

Trimethylsilyl (TMS) derivatives of the carbohydrate components were separated with a Becker-Packard model 419 gas chromatograph fitted with a column packed with OVI on chromosorb WAW (80/100 mesh).

Determination of protein

Protein was determined by the method of Lowry, Rosebrough, Farr & Randall (1951) using bovine serum albumin as standard.

RESULTS

1. Effect of enzyme concentration

As shown in Fig. 1 the initial reaction velocity of 0.02 M NaOH consumption was proportional to enzyme concentration (expressed as cm^3 enzyme solution).

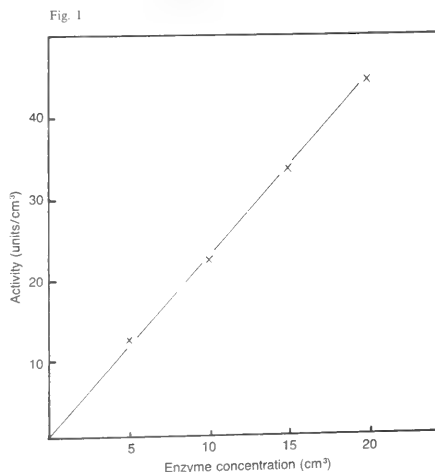


FIG. 1.

The effect of enzyme concentration on the reaction velocity of PME from Marvel tomatoes

2. Effect of pH

The effect of pH on the activity of PME shows the typical bell-shaped profile of enzyme activity against pH with an optimum at pH 7.5 (Fig. 2).

Fig. 2

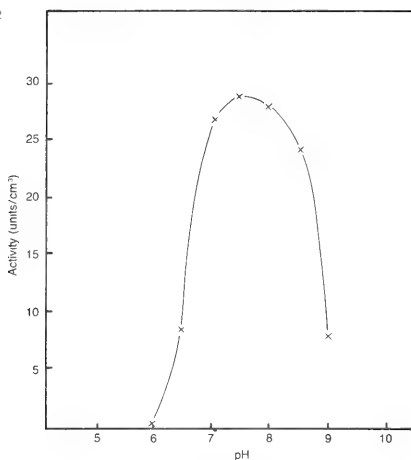


FIG. 2.

The effect of pH on the activity of PME from Marvel tomatoes.

3. Heat stability

The temperature profile of tomato PME in 0,15 M NaCl is illustrated in Fig. 3. It is evident that approximately 80 % activity remained after incubation at 50 °C for 5 min while only about 30 % residual activity remained after incubation at 60 °C. In spite of the initial heat resistance, the enzyme was completely inactivated at 70 °C for 5 min.

Fig. 3

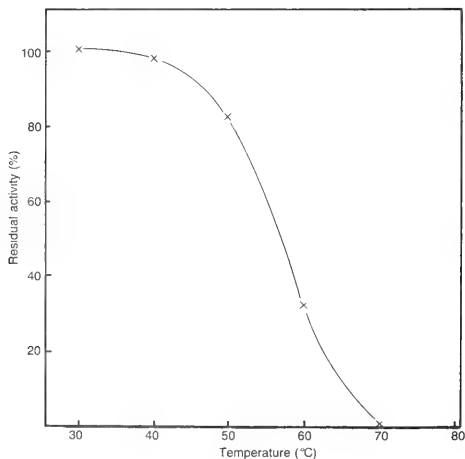


FIG. 3.

The effect of temperature on the activity of PME from Marvel tomatoes.

4. Effect of substrate

Fig. 4 shows the conventional double reciprocal plot of different pectin concentrations on the activity of the enzyme. A K_m -value of 0,1 % was obtained.

Fig. 4

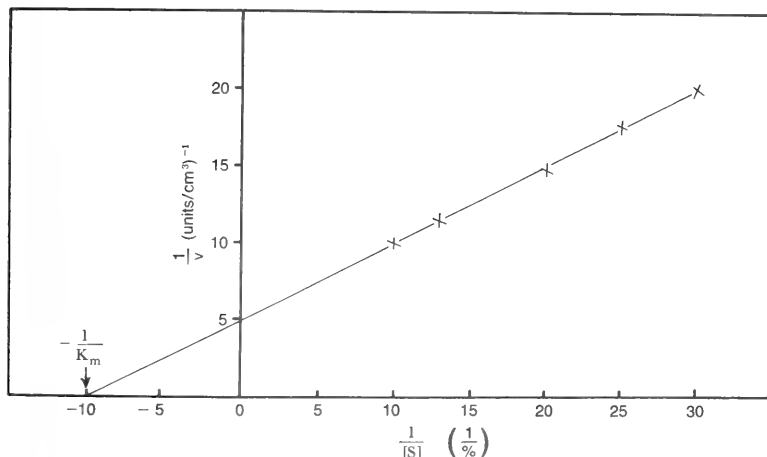


FIG. 4.

Lineweaver-Burk presentation of the effect of substrate concentration on the activity of PME from Marvel tomatoes.

TABLE 1.

Amino acid composition of purified PME from Marvel tomatoes

Components	Amino acid content (mg/100 mg)
Lysine	5,36
Histidine	0,93
Ammonia	4,08
Arginine	3,09
Asparagine/Aspartic Acid	9,51
Threonine	5,71
Serine	5,15
Glutamine/Glutamic Acid	6,91
Proline	4,40
Glycine	4,86
Alanine	4,91
Cysteine	*
Valine	3,39
Methionine	*
Isoleucine	3,33
Leucine	5,17
Tyrosine	2,89
Phenylalanine	2,72

*Trace amounts

5. Amino acid composition

Table 1 shows the amino acid composition of tomato PME. The presence of eighteen kinds of amino acids, with asparagine/aspartic acid and glutamine/glutamic acid present in the highest concentrations, were established in the enzyme. Tryptophan was not determined while only trace amounts of cysteine and methionine were found in the enzyme.

6. Carbohydrate composition

The carbohydrate composition of the enzyme is presented in Table 2. From this it is clear that five sugars are present in the enzyme with mannose and glucose present in the highest concentration.

TABLE 2.
Monosaccharides identified in the carbohydrate moiety of purified PME from Marvel tomatoes

Components	Carbohydrate content (mg/100 mg)
Arabinose	3,3
Xylose	2,0
Galactose	0,7
Mannose	6,8
Glucose	4,2

DISCUSSION

Some properties of PME from Marvel tomatoes are described in the present paper. The enzyme showed maximum activity at pH 7,5 compared to an optimum pH of 8,0 obtained by Nakagawa *et al.* (1970) in the Hikari variety of tomatoes. The K_m -value for citrus pectin was 0,1 % in comparison to that of 0,24 % found by Nakagawa *et al.* (1970).

In a previous paper we reported that PME contains carbohydrate (Theron *et al.*, 1977). Gas chromatographic analysis of the purified enzyme confirmed this, indicating the presence of five sugars in the enzyme. These results, suggesting a possible glycoprotein nature of the enzyme as was suggested by Delincée and Radola (1970), may probably be the reason for the apparent lack of a net charge on the enzyme (Theron *et al.*, 1977).

Similar to the results obtained by Nakagawa *et al.* (1970) the present study also revealed that PME from Marvel tomatoes is relatively heat stable. The presence of 18 kinds of amino acids were established in the purified enzyme. It was found that the amino acid composition of PME in the present study is very similar to that found by Nakagawa *et al.* (1970) in the Hikari variety of tomatoes except that the enzyme in the present study contains a small amount of histidine

and only trace amounts of cysteine and methionine since these amino acids were degraded during acid hydrolysis.

It is generally accepted that the intercellular cement of fruit cellwalls is attached by various pectic enzymes with the resultant loss of rigidity of the cells. However, the precise role of PME in such a function has not yet been established.

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PHENOLOGY OF THE VEGETATION IN THE HESTER MALAN NATURE RESERVE IN THE NAMAQUALAND BROKEN VELD:

2. THE THEROPHYTE POPULATION

MARGARETHA W. VAN ROOYEN,* N. GROBBELAAR and G. K. THERON

(Department of Botany, University of Pretoria)

ABSTRACT

The quantitative seasonal changes in therophyte populations were investigated by making monthly counts of the total number of plants in five, 1 m² plots. Densities ranged between 115 and 1 810 seedlings per m² in April. Of the total of 5 056 seedlings that emerged on the plots, 63,59 % reached maturity. The survival pattern varied between species as well as plots, but no clear relationships between the mortality of a plant species and particular abiotic factors could be demonstrated.

UITTREKSEL

'N FENOLOGIESE STUDIE VAN DIE PLANTEGROEI VAN DIE NAMA-KWALANDSE GEBROKE VELD:

2. DIE TEROFITIESE BEVOLKING

Die kwantitatiewe seisoenale veranderinge in terofitiese plantbevolkings is aan die hand van vyf, 1 m² persele ondersoek, waarop die aantal plante maandeliks aangeteken is. Digtheid van 115 tot 1 810 saailinge per m² is in April aangeteken. Van die totale 5 056 saailinge wat op die persele voorgekom het, het 63,59 % volwassenheid bereik. Verskillende spesies het verskillende oorlewingspatrone getoon, terwyl die persentasie oorlewing ook van perseel tot perseel gewissel het. Geen duidelike verband tussen die afsterwing van individue van 'n plantspesie en bepaalde abiotiese faktore kon aangetoon word nie.

INTRODUCTION

Although the perennial species undergo definite seasonal changes in appearance, it is the pronounced fluctuations in the ephemeral population of the region with its display of spring flowers which mainly attract attention. Not only do the ephemeral populations vary considerably between seasons and localities within a single year, but also from one year to another. For the seeds of the therophyte species to germinate and the seedlings to develop into mature plants in large numbers, a succession of specific environmental conditions is necessary. Due to the erratic nature of some of these conditions the seeds often fail to germinate. In some years many seedlings are produced, yet most perish before maturity. Consequently only once in about ten years, on average, do dense stands of therophytes develop in Namaqualand.

*Based on an M.Sc. thesis, University of Pretoria.

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Although many workers (Talbot, Biswell and Hormay, 1939; Went, 1948, 1949, 1955; Went and Westergaard, 1949; Juhren, Went and Phillips, 1956; Tevis, 1958a, 1958b; Beatley, 1967; Bykov, 1974) recognized seasonal fluctuations in the density and composition of desert therophyte populations, these fluctuations are not yet fully understood. From studies in the south eastern Californian portion of the Mojave Desert, Went (1955) concluded that desert annuals, once germinated, usually reach maturity, if only as depauperate and barely reproductive plants. The figures provided by Tevis (1958b) for the Sonoran Desert in California and Beatley (1967) for the northern Mojave Desert in Nevada, however, indicate that it rarely happens that more than 50 % of the seedlings survive. Similar studies had not been undertaken in Namaqualand prior to the present investigation which attempts to measure changes in the composition of therophyte populations during a growing season. The results presented in this paper are from a restricted area and for one season only and are therefore not offered as norms for describing the whole Namaqualand Broken Veld.

METHODS

After the good rains (55,5 mm) which fell in March 1974, five areas with fairly dense stands of therophyte seedlings were selected in April 1974 in the Hester Malan Nature Reserve near Springbok (Rösch, 1977; Van Rooyen, Theron and Grobbelaar, 1979). In each of five areas a square metal frame was permanently placed so as to include a representative portion of that area. The position of every seedling within the plots was carefully mapped on graph paper. The plots were visited at monthly intervals until September 1974. During these visits the positions of new seedlings were mapped while the death of others was noted. During the last visit (in September), those therophyte individuals which, though still alive, were on the verge of dying and had not yet flowered, were excluded from the September count. Only in the case of seedlings of perennial species, were immature plants included in the September count. Although the seedlings of perennial species are not part of the therophyte population, they were included in the monthly counts because it was impossible to identify all species during the first few months. Barring plot 5, where a substantial number of these seedlings occurred, only six other seedlings of perennial species were noted, three in each of plots 1 and 2.

RESULTS AND DISCUSSION

The experimental plots

Some of the physical characteristics of the plots are summarized in Table 1. Although a few therophyte species occurred in several plots, no two plots had the same species composition (Table 2).

TABLE 1
Selected characteristics of the phenological study sites in the Hester Malan Nature Reserve

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Height above sea level (m)	1 180	1 210	1 260	1 260	1 080
Slope	—	5°	—	5°	—
Aspect	—	WNW	—	SSW	—
Geological formation	Transition	Gneiss	Transition	Granitic gneiss	Gneiss
Surface erosion (1-4)*	3	3	2	2	4
Stoniness (0-5)*	2	3	0	2	0
Soil depth (m)	0,3	0,25	>0,5	0,3	0,35
Biotic influences	Insect damage	Insect damage Grazing	Insect damage Grazing	Insect damage	Insect damage Grazing
Disturbance	Alongside road	—	Abandoned land	Old "kraal"	Water course

*Scale according to Loxton (1966)

TABLE 2

Species composition of the five plots used for phenological studies in the Hester Malan Nature Reserve. Perennial plant species are included and marked with an asterisk

Species	Plot				
	1	2	3	4	5
Aizoon canariense	×	×		×	×
*Aptosimum indivisum					×
Arctotis fastuosa	×			×	×
Cotula barbata			×		
Crotalaria micrantha	×		×		
Diascia tanyceras	×				
Dimorphotheca sinuata	×	×			×
Dischisma spicatum	×		×		
Erodium cicutarium	×			×	
Felicia merxmuellerei	×			×	
*Galenia africana	×				×
G. filiformis	×	×		×	
Helichrysum obtusum var. obtusum	×		×		
Heliophila pectinata	×	×		×	
H. variabilis			×		
*Hermannia meyeriana			×		
*Herrea blanda			×		
*Hypertelis salsoloides					×
Ifloga paronychioides	×				
Karoochloa schismoides		×			
*Lachenalia ovatifolia			×		
*Lebeckia sericea		×			
*Leyssera gnaphalioides			×		
L. tenella	×	×		×	
Lotononis depressa					×
Manulea cheiranthus	×	×			
Mesembryanthemum karrooense			×	×	
Mesembryanthemum sp.			×		
Micropterum papulosum	×	×			
Nemesia azurea		×			×
Osteospermum amplexans		×			×
O. hyoseroides	×	×			×
*Oxalis campylorrhiza					×
*O. furcillata					×
*O. obtusa	×	×	×	×	×
*Peliosostomum virgatum					×
*Pentstemon tomentella			×		
Pentzia albida				×	
P. suffruticosa				×	
Pharnaceum croceum			×		
Polycarena pubescens			×		
Schismus barbatus	×	×		×	
Senecio cardaminefolius	×			×	
Tetragonia microptera	×	×		×	
*Trachyandra flexifolia	×		×		
*Trachyandra sp.				×	
Ursinia cakilefolia			×		
U. calenduliflora					×
U. nana subsp. nana	×			×	×
Zaluzianskya benthamiana	×			×	×

Plot 1

In plot 1 *Micropterum papulosum*, a small inconspicuous prostrate therophyte, was the most abundant species (Table 3). The seedlings of *Leyssera tenella*, *Dischisma spicatum*, *Erodium cicutarium*, *Zaluzianskya benthamiana* and *Ursinia nana* subsp. *nana* did not develop into large plants but nevertheless produced a few flowers. *Tetragonia microptera*, *Aizoon canariense*, *Galenia filiformis* and *Ifloga paronychioides* were less numerous but are also relatively inconspicuous species. Although not very abundant, *Osteospermum hyoseroides* was the most conspicuous species in plot 1.

Plot 2

This plot (Table 4), like plot 5, contained considerably less seedlings than the other sites (Tables 3 to 7). Although *Tetragonia microptera* plants were more abundant than *Osteospermum hyoseroides* plants, the latter appeared to be the dominant species because they were larger and more conspicuous. A significant feature of this plot was the large number of *Heliophila pectinata* seedlings which emerged in July.

Plot 3

Cotula barbata dominated this site (Table 5) both in numbers and appearance. These plants, however, were very small and consisted of a few leaves at the base and a solitary inflorescence. In many cases the leaves could no longer be distinguished by the time the inflorescence was produced. Despite high mortality rates, *Dischisma spicatum* and *Pharnaceum croceum* were fairly conspicuous during September. The following perennial species, which sprouted after their dormant period during summer, were noted in the plot in April: *Pentaschistis tomentella*, *Leyssera gnaphalioides*, *Lachenalia ovatifolia*, *Trachyandra flexifolia* and *Oxalis obtusa*.

Plot 4

In this plot *Leyssera tenella* was the most abundant species (Table 6). These plants remained small and produced few flowers. The *Arctotis fastuosa* plants also did not grow much and started flowering at an early date. In this plot there were several species such as *Pentzia albida* and *P. suffruticosa* whose seeds germinated over a long period—from March to June.

Plot 5

This plot (Table 7) displayed the smallest number of plants throughout the experimental period. Seedlings of perennial species, such as *Peliostomum virgatum* and *Hypertelis salsoloides* occurred in fairly large numbers in this plot. Another noteworthy aspect of plot 5 was the large number of *Oxalis* plants which emerged from it.

TABLE 3
The size and composition of the population of plot 1 (1 m²) in the Hester Malan Nature Reserve as determined at monthly intervals from April to September 1974

Species	April			May			June			July			August			September		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
<i>Micropteris populosum</i>	859	73.04	100.00	777	70.83	90.45	660	71.82	76.83	565	69.58	65.77	483	68.03	56.23	449	67.82	52.27
<i>Leyseria tenella</i>	135	11.48	100.00	133	12.12	98.52	112	12.19	82.96	108	13.30	80.00	99	13.94	73.33	92	13.90	68.15
<i>Teragonia microptera</i>	55	4.68	100.00	53	4.83	96.36	36	3.92	65.45	19	2.34	34.55	13	1.84	23.64	12	1.81	21.82
<i>Dischisma spicatum</i>	26	2.21	100.00	26	2.37	100.00	14	1.52	53.85	11	1.35	42.31	9	1.27	34.62	9	1.36	34.62
<i>Erodium cicutarium</i>	19	1.62	82.61	23	2.10	100.00	20	2.18	86.96	21	2.59	91.30	21	2.96	91.30	20	3.02	86.96
<i>Zaluzianskya benthamiana</i>	18	1.53	90.00	20	1.82	100.00	18	1.96	90.00	12	1.48	60.00	11	1.55	55.00	11	1.66	55.00
<i>Ursinia nana</i> subsp. <i>nana</i>	12	1.02	100.00	11	1.00	91.67	10	1.09	83.33	11	1.35	91.67	9	1.27	75.00	8	1.21	66.67
<i>Osteospermum hyoseroides</i>	10	0.85	100.00	10	0.91	100.00	10	1.09	100.00	10	1.23	100.00	10	1.41	100.00	10	1.51	100.00
<i>Alizoon canariense</i>	8	0.68	100.00	8	0.73	100.00	7	0.76	87.50	7	0.86	87.50	7	0.99	87.50	6	0.91	75.00
<i>Galenia filiformis</i>	6	0.51	100.00	6	0.57	100.00	5	0.54	83.33	5	0.62	83.33	5	0.70	83.33	5	0.76	83.33
<i>Ifloga paronychioides</i>	6	0.51	85.71	7	0.64	100.00	5	0.54	71.43	6	0.74	85.71	6	0.84	85.71	6	0.91	85.71
<i>Dimorphotheca sinuata</i>	5	0.43	100.00	5	0.46	100.00	4	0.44	80.00	4	0.49	80.00	4	0.56	80.00	4	0.60	80.00
<i>Helichrysium obtusum</i> var. <i>obtusum</i>	5	0.43	100.00	5	0.46	100.00	5	0.54	100.00	5	0.62	100.00	4	0.56	80.00	4	0.60	80.00
<i>Manulea celtiranthus</i>	4	0.34	100.00	4	0.36	100.00	4	0.44	100.00	2	0.25	50.00	2	0.28	50.00	2	0.30	50.00
<i>Arctotis fastuosa</i>	3	0.26	100.00	3	0.27	100.00	3	0.33	100.00	2	0.25	66.67	2	0.28	66.67	2	0.30	66.67
<i>Crotalaria micrantha</i>	3	0.26	100.00	2	0.18	66.67	1	0.11	33.33	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
<i>Diascia tanyceras</i>	1	0.09	100.00	1	0.09	100.00	1	0.11	100.00	1	0.12	100.00	1	0.14	100.00	1	0.15	100.00
* <i>Galenia africana</i>	1	0.09	100.00	1	0.09	100.00	1	0.11	100.00	1	0.12	100.00	2	0.28	100.00	2	0.30	100.00
*Species 1	1	0.09	100.00	2	0.18	100.00	1	0.11	12.50	6	0.74	75.00	8	1.13	100.00	8	1.21	100.00
<i>Schismus barbatus</i>							1	0.11		10	1.23	100.00	8	1.13	80.00	6	0.91	60.00
<i>Senecio cardamineifolius</i>										3	0.37	100.00	3	0.42	100.00	3	0.45	100.00
<i>Heliphila pectinata</i>										1	0.12	50.00	2	0.28	100.00	1	0.15	50.00
<i>Felicia merxmuellieri</i>																		
Total	1 176	100.03	100.00	1 097	100.01	90.59	919	100.02	75.89	812	100.00	67.05	710	99.99	58.63	662	99.99	54.67

* Perennial species.

a. Number of live individuals present.

b. Number of live individuals present as a percentage of the month's total live plant population = relative abundance.

c. Number of live individuals present as a percentage of the largest monthly live count for this species during the whole experimental period (6 months)—PMP (Percentage of Maximum Presence).

d. Total number of live individuals on plot as a percentage of the total number of seedlings that emerged during the whole experimental period (6 months).

TABLE 4
The size and composition of the population of plot 2 (1 m²) in the Hester Malan Nature Reserve as determined at monthly intervals from April to September 1974

Species	April			May			June			July			August			September		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
<i>Tetragonia microptera</i>	137	68.84	100.00	129	68.98	94.16	98	63.64	71.53	78	44.83	56.93	69	43.95	50.36	61	41.78	44.53
<i>Osteospermum hyosyroides</i>	38	19.10	100.00	35	18.72	92.11	35	22.73	92.11	33	18.97	86.84	33	21.02	86.84	31	21.23	81.58
<i>Galenia filiformis</i>	7	3.52	100.00	7	3.74	100.00	5	3.25	71.43	5	2.87	71.43	5	3.18	71.43	5	3.43	71.43
<i>Dimorphotheca sinuata</i>	6	3.02	100.00	6	3.21	100.00	6	3.90	100.00	5	2.87	83.33	5	3.18	83.33	5	3.43	83.33
<i>Arizon canariense</i>	5	2.51	100.00	5	2.67	100.00	4	2.60	80.00	2	1.15	40.00	1	0.64	20.00	0	0.00	0.00
<i>Osteospermum amplexans</i>	3	1.51	100.00	2	1.07	66.67	2	1.30	66.67	2	1.15	66.67	2	1.27	66.67	2	1.37	66.67
* <i>Lebeckia sericea</i>	1	0.50	100.00	1	0.53	100.00	1	0.65	100.00	1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
<i>Manilia cheiranthus</i>	1	0.50	100.00	1	0.53	50.00	1	0.65	50.00	2	1.15	100.00	2	1.27	100.00	2	1.37	100.00
<i>Micropteris papulosum</i>	1	0.50	50.00	1	0.53	100.00	1	0.65	100.00	1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
<i>Heliphila pectinata</i>	1	0.50	100.00	1	0.53	100.00	1	0.65	3.57	28	16.09	100.00	28	17.83	100.00	26	17.81	92.86
<i>Schismus barbatus</i>										3	1.72	50.00	4	2.55	66.67	6	4.11	100.00
<i>Karoochoia schismoides</i>										1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
<i>Leysseria tenella</i>										1	0.57	33.33	3	1.91	100.00	2	1.37	66.67
<i>Nemesia azurea</i>										1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
*Species 2										1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
*Species 3										1	0.57	100.00	1	0.64	100.00	1	0.68	100.00
Total	199	100.00	100.00	187	99.98	77.59	154	100.02	63.90	164	100.00	68.04	157	100.00	64.15	146	99.96	60.58

* Perennial species

a. Number of live individuals present

b. Number of live individuals present as a percentage of the month's total live plant population = relative abundance.

c. Number of live individuals as a percentage of the largest monthly count for this species during the whole experimental period (6 months)—PMP (Percentage of Maximum Presence).

d. Total number of live individuals on the plot as a percentage of the total number of seedlings that emerged during the whole experimental period (6 months).

TABLE 5
The size and composition of the population of plot 3 (1 m²) in the Hester Malan Nature Reserve as determined at monthly intervals from April to September 1974

Species	April			May			June			July			August			September		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
<i>Conula barbata</i>	1 558	86.08	100.00	1 419	87.16	91.08	1 332	92.63	85.49	1 293	92.75	82.99	1 269	93.10	81.45	1 254	93.44	80.49
<i>Dischisma spicaeum</i>	143	7.90	100.00	109	6.70	76.22	59	4.10	41.25	57	4.09	39.86	51	3.74	35.66	50	3.73	34.96
<i>Pharacaeum croceum</i>	67	3.70	100.00	64	3.93	95.52	25	1.74	37.31	24	1.72	35.82	23	1.69	34.33	20	1.49	29.85
<i>Crotalaria micrantha</i>	13	0.72	100.00	8	0.49	61.54	2	0.14	15.38	1	0.07	7.69	1	0.07	7.69	1	0.07	7.69
<i>Polycarpha pubescens</i>	13	0.72	100.00	13	0.80	100.00	10	0.70	76.92	10	0.72	76.92	10	0.73	76.92	10	0.75	76.92
<i>Heliotropia pectinata</i>	4	0.22	100.00	4	0.24	100.00	3	0.21	75.00	1	0.07	25.00	1	0.07	25.00	0	0.00	0.00
<i>Mesembryanthemum speciosum</i>	4	0.22	100.00	2	0.12	50.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
<i>Helictotris obusum</i> var. <i>obusum</i>	3	0.17	100.00	3	0.18	100.00	2	0.14	66.67	3	0.22	100.00	3	0.22	100.00	3	0.22	100.00
<i>Ursinia cackilefolia</i>	3	0.17	100.00	3	0.18	100.00	3	0.21	100.00	3	0.22	100.00	3	0.22	100.00	3	0.22	100.00
<i>Mesembryanthemum karroense</i>	1	0.06	100.00	1	0.06	100.00	1	0.07	100.00	1	0.07	100.00	1	0.07	100.00	1	0.07	100.00
Species 4	1	0.06	100.00	1	0.06	100.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Species 5	1	0.06	100.00	1	0.06	100.00	1	0.07	100.00	1	0.07	100.00	1	0.07	100.00	0	0.00	0.00
Total	1 810	100.02	100.00	1 628	99.98	89.85	1 438	100.01	79.36	1 394	100.00	76.93	1 363	99.98	75.22	1 342	99.99	74.06

a. Number of live individuals present.

b. Number of live individuals present as a percentage of the month's total live plant population = relative abundance.

c. Number of live individuals present as a percentage of the largest monthly count for this species during the whole experimental period (6 months).—PMP (Percentage of Maximum Presence).

d. Total number of live individuals on the plot as a percentage of the total number of seedlings that emerged during the whole experimental period (6 months).

TABLE 6
The size and composition of the population of plot 4 (1 m²) in the Hester Malan Nature Reserve as determined at monthly intervals from April to September 1974

Species	April			May			June			July			August			September		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
<i>Leyseria tenella</i>	1 301	79.62	100.00	1 059	79.03	81.40	961	76.70	73.89	828	73.86	63.64	784	74.38	60.26	753	74.85	57.88
<i>Arctotis fastuosa</i>	194	11.87	100.00	164	12.24	84.54	160	12.77	82.43	160	14.27	82.47	145	13.76	74.74	138	13.72	71.13
<i>Senecio cardanifolius</i>	29	1.77	100.00	13	0.97	44.83	11	0.88	37.93	9	0.80	31.03	7	0.66	24.14	6	0.60	20.69
<i>Tetragonia microptera</i>	27	1.65	100.00	25	1.87	83.33	30	2.39	100.00	30	2.68	100.00	28	2.66	93.33	26	2.58	86.67
<i>Zaluzianskya benthamiana</i>	19	1.16	100.00	15	1.12	78.95	17	1.36	89.47	15	1.34	78.95	12	1.14	63.16	10	0.99	52.63
<i>Penzia alba</i>	16	0.98	76.19	15	1.12	71.43	18	1.44	85.71	21	1.87	100.00	21	1.99	100.00	21	2.09	100.00
<i>Galenia filiformis</i>	12	0.73	92.31	13	0.90	92.31	13	1.04	100.00	13	1.16	100.00	13	1.23	100.00	12	1.19	92.31
<i>Erodium cicutarium</i>	10	0.61	100.00	6	0.45	60.00	6	0.48	60.00	5	0.45	50.00	5	0.47	50.00	4	0.40	40.00
<i>Albizia canariense</i>	7	0.43	63.64	9	0.67	81.82	10	0.80	90.00	11	0.98	100.00	11	1.04	100.00	10	0.99	90.91
<i>Mesembryanthemum karrooense</i>	7	0.43	100.00	5	0.37	71.43	5	0.40	71.43	5	0.45	71.43	5	0.47	71.43	5	0.50	71.43
<i>Penzia suffruticosa</i>	5	0.31	27.78	12	0.90	66.67	16	1.28	88.89	18	1.61	100.00	18	1.71	100.00	16	1.59	88.89
<i>Schismus barbatus</i>	5	0.31	100.00	3	0.22	60.00	3	0.24	60.00	3	0.27	60.00	1	0.09	20.00	1	0.10	20.00
<i>Ursinia nana</i> subsp. <i>nana</i>	2	0.12	100.00	1	0.07	50.00	1	0.08	50.00	1	0.09	50.00	1	0.09	50.00	1	0.10	50.00
<i>Felicia merxmulleri</i>	2	0.12	100.00	1	0.07	50.00	1	0.08	50.00	1	0.09	50.00	2	0.19	100.00	2	0.20	100.00
<i>Helipolia pectinata</i>	1	0.07	100.00	1	0.07	50.00	1	0.08	100.00	1	0.09	100.00	1	0.09	100.00	1	0.10	100.00
Total	1 634	99.99	100.00	1 340	100.00	80.34	1 253	100.02	75.12	1 121	100.01	67.21	1 054	99.97	63.19	1 006	100.00	60.31

a. Number of live individuals present.

b. Number of live individuals present as a percentage of the month's total live plant population = relative abundance.

c. Number of live individuals present as a percentage of the largest monthly count for this species during the whole experimental period (6 months)—PMP (Percentage of Maximum Presence).

d. Total number of live individuals on the plot as a percentage of the total number of seedlings that emerged during the whole experimental period.

TABLE 7
The size and composition of the population of plot 5 (1 m²) in the Hester Malan Nature Reserve as determined at monthly intervals from April to September 1974

Species	April			May			June			July			August			September		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
* <i>Pellissium virgatum</i>	35	30.43	100.00	27	30.34	77.14	31	42.47	88.57	31	41.89	88.57	28	44.44	80.00	26	44.07	74.29
<i>Oscospermum amplexiens</i>	18	15.65	100.00	18	20.22	100.00	18	24.66	100.00	17	22.97	94.44	16	25.40	88.88	16	27.12	88.88
<i>Dimorphotheca sinuata</i>	17	14.78	100.00	13	13.48	70.59	10	13.70	58.82	9	12.16	52.94	8	12.70	47.06	8	13.56	47.06
* <i>Hypertelis salicoides</i>	5	4.35	100.00	1	1.12	20.00	1	1.37	20.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
<i>Ursinia calanduliflora</i>	5	4.35	100.00	3	3.37	60.00	1	1.37	20.00	1	1.35	20.00	1	1.59	20.00	1	1.69	20.00
<i>Zaluzianskya benthamiana</i>	4	3.48	100.00	2	2.25	50.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
<i>Atizoon canariense</i>	4	3.48	100.00	4	4.49	100.00	3	4.11	75.00	3	4.05	75.00	4	6.34	100.00	3	5.08	75.00
<i>Acrotis fastuosa</i>	4	3.48	100.00	4	4.49	100.00	4	5.48	100.00	4	5.41	100.00	4	6.34	100.00	3	5.08	75.00
<i>Oscospermum hyoseroides</i>	2	1.74	100.00	2	2.25	100.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
* <i>Galenia africana</i>	2	1.74	100.00	2	2.25	100.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
<i>Lozonis depressa</i>	1	0.87	100.00	1	1.12	100.00	1	1.37	50.00	1	1.35	100.00	1	1.59	100.00	1	1.69	100.00
* <i>Aptosis indivisum</i>	1	0.87	100.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Species 6	1	0.87	100.00	0	0.00	0.00	1	1.37	50.00	2	2.70	100.00	1	1.59	50.00	1	1.69	50.00
<i>Nemesia azurea</i>										2	2.70	100.00	0	0.00	0.00	0	0.00	0.00
Species 7										1	1.35	100.00	1	1.59	100.00	0	0.00	0.00
<i>Ursinia nana</i> subsp. <i>nana</i>																		
Total	115	100.00	100.00	89	99.99	71.77	73	100.01	58.87	74	99.98	59.68	63	100.00	50.81	59	99.98	47.58
d																		

* Perennial species.

a. Number of live individuals present.

b. Number of live individuals present as a percentage of the month's total live plant population = relative abundance.

c. Number of live individuals present as a percentage of the largest monthly count for this species during the whole experimental period (6 months)—PMP (Percentage of Maximum Presence).

d. Total number of individuals present on the plot as a percentage of the total number of seedlings that emerged during the whole experimental period (6 months).

As mentioned in the previous paper in this series (Van Rooyen, Theron and Grobbelaar, 1979) in which a general description of the phenology of the vegetation of the area was presented, March was regarded as the beginning of the 1974 growing season for the therophytes, because of the good rains during that month. Growth during the winter months was slow and only after temperatures began to rise in spring, did the growth rate increase. October was regarded as the end of the growing season for therophytes in 1974.

The results of the data collected during the period April to November 1974 are presented in Tables 3 to 7 and Figures 1 to 5.

Germination

During the experimental period by far the most seeds of a particular species and seeds of the largest number of different species germinated after the rains from 10 to 13 March (Tables 3 to 7). As a result no less than 1 558 seedlings of *Cotula barbata* (plot 3), 1 301 seedlings of *Leyssera tenella* (plot 4) and 859 seedlings of *Micropterum papulosum* (plot 1) were counted in the plots in April. Between the April and May counts, only a few seeds of a small number of species germinated, whereas a fairly large number of seedlings emerged between the June and July counts. Among the seedlings which emerged in June, presumably as a result of the 28,7 mm of rain which fell early in June, those of *Heliophila pectinata* were especially abundant. During the next two months (July and August) only a few seeds of a small number of species germinated.

For all plots it was found that the density of the total number of seedlings per plot was the highest during April, when the counts ranged from 115 seedlings per m^2 (plot 5) to 1 810 seedlings per m^2 (plot 3). The highest density that was recorded for a single species was 1 558 seedlings per m^2 (plot 3) for *Cotula barbata* during the April count. Compared with the results from other deserts or semi-deserts in California, these densities are not particularly high. Went and Westergaard (1949) recorded up to 5 000 seedlings per m^2 in the Death Valley National Park, while Tevis (1958b) found a total of up to 1 112 seedlings per m^2 in the Sonoran Desert. In Mendocino County, Heady (1956) recorded 54 250 plants per m^2 (35 per square inch) whilst Biswell and Graham (1956) found 224 696 seedlings per m^2 (20 875 per square foot) in dense stands of *Festuca megalura* in Madera County.

Survival

The PMP-values* (Tables 3 to 7) of the most conspicuous species in each plot for the period April to September 1974 are diagrammatically presented in Figures 1 to 5. For most species there was a decrease in the number of individuals per plot

*Percentage of Maximum Presence—number of live individuals present as a percentage of the largest monthly live count for this species during the whole experimental period.

from one count to the next. Because of the increase in volume of the surviving plants this reduction in numbers was not so noticeable in the field. The monthly PMP-values of a species indicate the percentage of individuals surviving. In the case of the therophytes the September PMP-values represent the percentage of each species which completed its life cycle successfully.

Results show that the percentage of the whole population that survived from April to September varied from 47,58 % (plot 5) to 74,06 % (plot 3) between plots. For the different species within a plot, the number of seedlings which developed into mature plants varied from 0,00 % to 100,00 % of the total that emerged.

Survival of species on a study site, *i.e.* at least one individual of the species reached maturity on the study site, ranged from 62,5 % (plot 5) to 100,00 % (plot 4) between plots. If, however, the results of all plots are considered together, *i.e.* at least one individual of the species reached maturity at any of the study sites, the percentage survival of species was 85,3 %.

The PMP-values for a given species were not always constant for the different sites. These differences in survival for the same species can possibly be related to differences in the micro-environment of the sites. For instance, the percentage survival of *Tetragonia microptera* was 21,82 % at plot 1; 44,53 % at plot 2 and 86,67 % at plot 4. On the other hand, *Dischisma spicatum* showed a rather constant percentage survival for plots 1 and 3, the values being 34,62 % and 34,96 % respectively.

The variable response of the species to the environment is reflected in the differences in percentage relative abundance in successive months at one study site (Tables 3 to 7). Provided the total number of individuals at one site does not increase in successive months due to the emergence of new seedlings, one can deduce that a species is well adapted to the environment if the number of live plants as a percentage of all the live plants in the plot, increases from one month to the next. For instance, the relative abundance of *Osteospermum hyoseroides* and *Erodium cicutarium* consistently increased during the whole experimental period in plot 1 and these species can therefore possibly be regarded as being better adapted to the environment than many of the other species also occurring in the plot. Conversely, if, in the absence of further seed germination within the plot, the relative abundance of a species decreases in time, this could signify that relative to the other species in the plot, this species is not so well adapted to the prevailing environmental conditions. From the present results it would therefore appear that *Dischisma spicatum*, *Pharnaceum croceum* and *Crotalaria micrantha* were not so well adapted to the environment as the other species in plot 3. In the case of *Dimorphotheca sinuata* in plot 5, the decrease in relative abundance during the six month period, appeared to be due to selective grazing by animals.

Of the total of 5 056 seedlings encountered in the five plots during the period from April to September, 63,59 % survived. This represents a somewhat better survival value than has been reported for other arid regions. Despite the fact that

Juhren, Went and Phillips (1956) conclude that "most seedlings survive", their results for the Joshua Tree National Monument in California show a range of 9–71 % survival on different sites and of the total original seedling population only 46 % survived. The results of Tevis (1958b) for the Coachella Valley, Sonoran Desert in California show survival values from 0–73 % for 12 different species and of the total original seedling population 49.78 % reached maturity. Beatley (1967) working in the northern Mojave Desert in southern Nevada, reported that the percentage seedlings that reached maturity in two successive years was 38 % and 60 % respectively. The growing seasons in the two cases were 7 to 8 months and 6 to 10 weeks respectively. These two growing seasons represent the extremes in length which appear possible for winter annuals of that region (Beatley, 1967)

Mortality

A decrease in time of the PMP-value (Tables 3 to 7 and Figures 1 to 5) for a given species represents the approximate mortality of that species during the period. The true mortality can, however, be higher than the approximate value if new seedlings emerge while others perish in the same month. As this rarely happened to a significant extent during one month, the approximate value for the monthly mortality of a species generally can be regarded as the true mortality for the month. According to these values the largest number of individuals died in the plots during April and May.

The mortality rate, however, should be expressed as the number of individuals perishing during one month as a percentage of the number of individuals present in the beginning of the month. The mortality rate of the different species does not show a constant pattern, neither does it seem possible to correlate the mortality rate with any environmental factors. All stages in the life cycle of a plant are not necessarily equally sensitive to unfavourable environmental factors and this probably explains the lack of an obvious mortality pattern.

Tevis (1958b) reported that the only significant cause of mortality for any species was moisture-stress, whereas Beatley (1967) states that the fate of any given individual is apparently related to its location relative to microvariations in moisture in the upper 80 to 200 mm of soil and to the effectiveness with which its root system penetrates the soil volume in advance of others.

As a possible explanation for the differences in species composition of therophyte populations from year to year, it has been suggested that the temperatures prevailing at the time of the infrequent rainfall, determine which species will germinate (Went, 1948, 1949; Went and Westergaard, 1949; Juhren, Went and Phillips, 1956; Tevis, 1958a, 1958b). This statement is based on the fact that each species has its own and often very narrow requirements for germination. As a result of favourable rainfall-temperature combinations one species may dominate

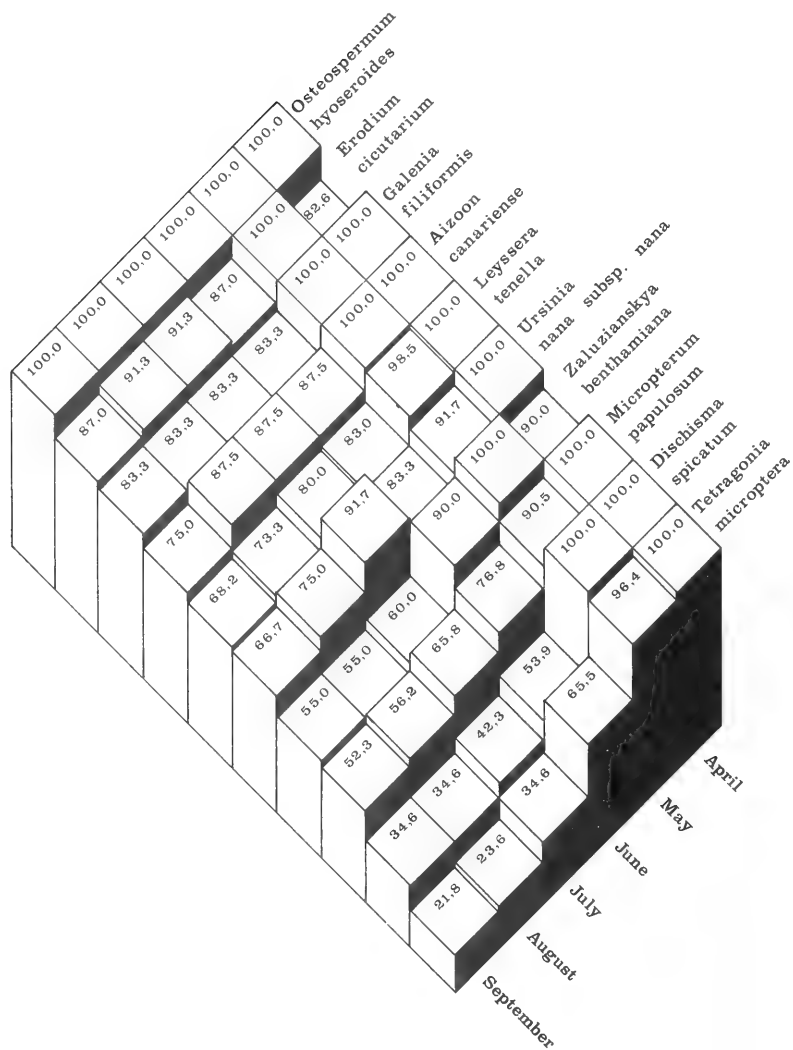


FIG. 1

The PMP-values (Percentage of Maximum Presence) of the most conspicuous species in plot 1 in the Hester Malan Nature Reserve from April to September 1974.

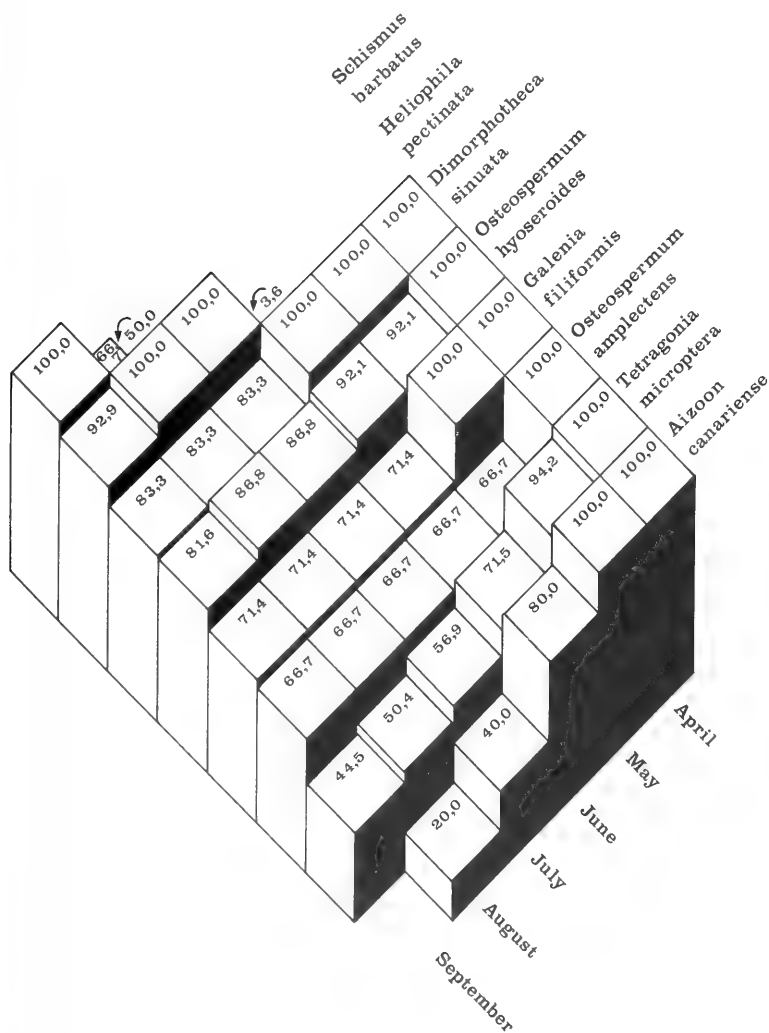


FIG. 2

The PMP-values (Percentage of Maximum Presence) of the most conspicuous species in plot 2 in the Hester Malan Nature Reserve from April to September 1974.

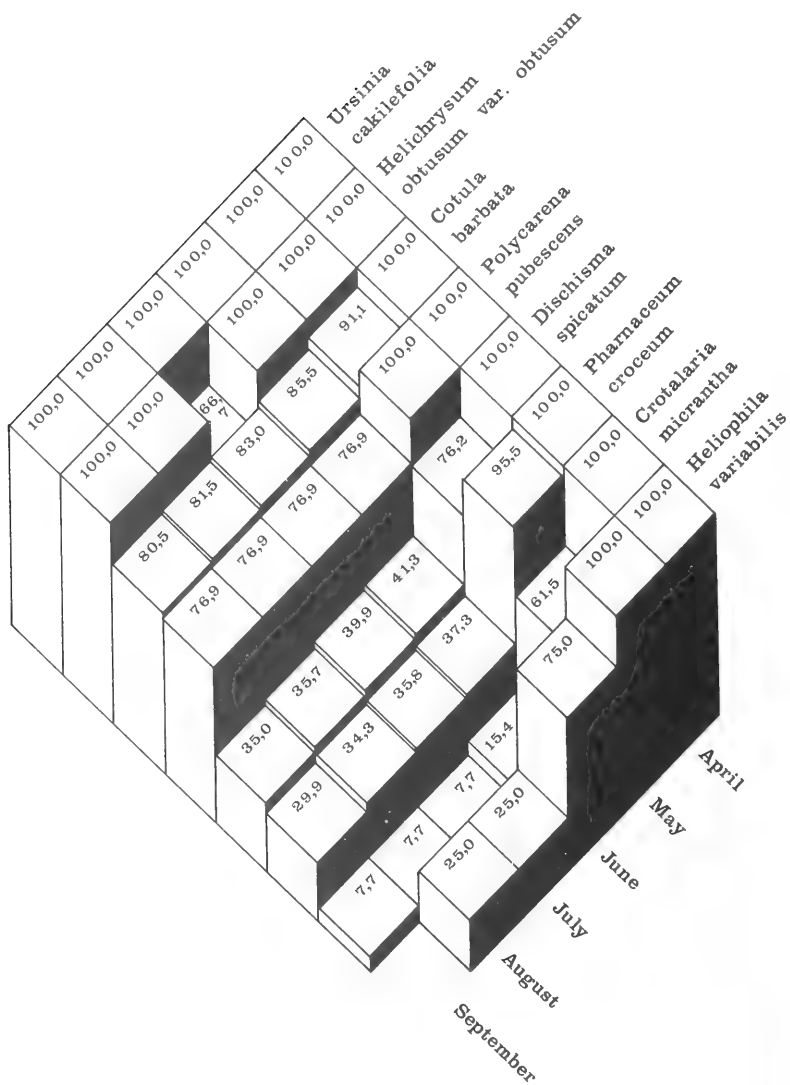


FIG. 3

The PMP-values (Percentage of Maximum Presence) of the most conspicuous species in plot 3 in the Hester Malan Nature Reserve from April to September 1974.

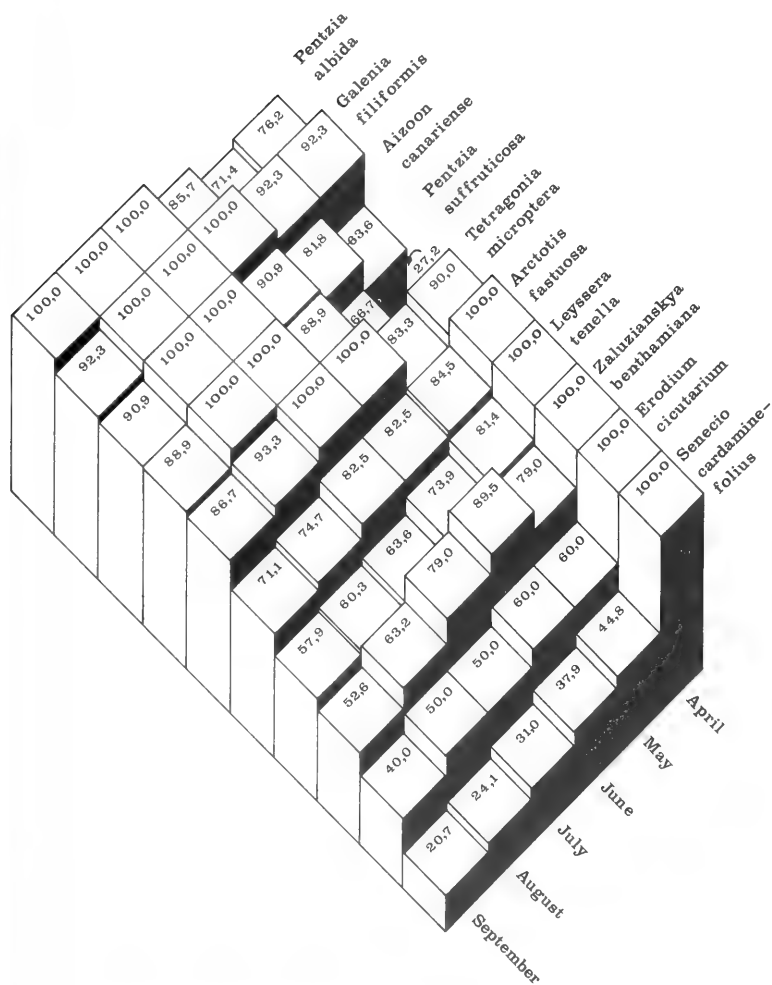


FIG. 4

The PMP-values (Percentage of Maximum Presence) of the most conspicuous species in plot 4 in the Hester Malan Nature Reserve from April to September 1974.

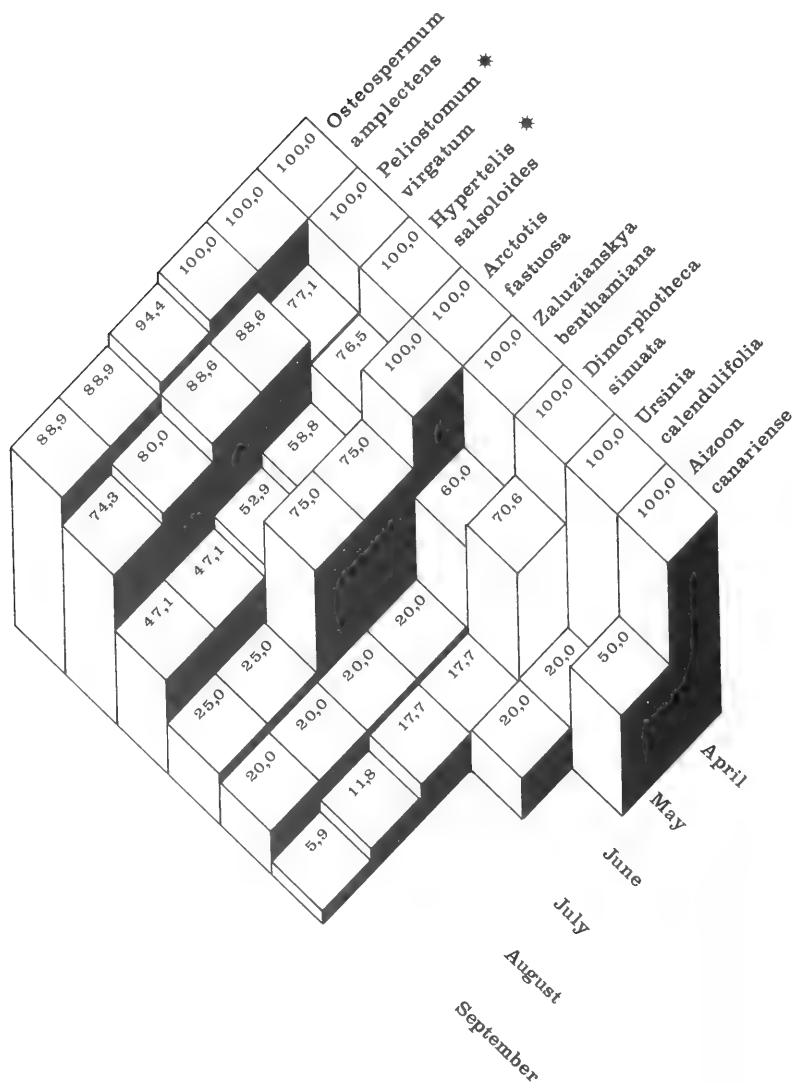


FIG. 5

The PMP-values (Percentage of Maximum Presence) of the most conspicuous species in plot 5 in the Hester Malan Nature Reserve from April to September 1974. Perennial species marked with an asterisk.

the landscape in one year; while in the next year, they may hardly be noticeable at all and quite a different species may appear to be dominant.

SUMMARY

In the beginning of April 1974 five 1 m² plots were laid out and all seedlings in the plots were mapped and counted. The plots were visited at monthly intervals and all new seedlings were added and the death of others noted. From these results the following values were calculated for each species:

- monthly percentage of maximum population (PMP-value);
- monthly relative abundance; and
- monthly mortality rate (not included in Tables 3 to 7).

The largest number of seeds germinated in March and densities from 115 to 1 810 seedlings per square metre were reported on the plots in the beginning of April. A relatively small number of seeds germinated later during the season.

Of the total of 5 056 seedlings found in the plots 3 215 (63,59 %) reached maturity. The percentage survival of individuals at one site ranged from 47,58 % to 74,06 % between plots and from 0,00 % to 100,00 % between species. If the results of all the plots are considered together the percentage survival of species was 85,3 %.

An increase or a decrease in the relative abundance of a species indicates the adaptability of a species to the prevailing environmental conditions as compared with the other species also occurring in the same plot.

The largest number of individuals died during April and May but no clear correlations could be demonstrated between the mortality rate and abiotic environmental conditions.

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SHORT COMMUNICATION

**SHOULD THERE BE MORE TREE VEGETATION IN THE
MEDITERRANEAN CLIMATIC REGION OF SOUTH AFRICA?**

B. M. CAMPBELL*

B. MCKENZIE**

E. J. MOLL

(*Department of Botany, University of Cape Town*)

ABSTRACT

Recent comparative studies of the forest vegetation of the mediterranean regions of California and South Africa, general accounts of the vegetation of the mediterranean regions of the world, and the spread of introduced trees and tall shrubs into the indigenous fynbos vegetation of South Africa, suggest that the South African mediterranean region should support a much more extensive tree vegetation.

UITTREKSEL

BEHOORT DAAR 'N GROTER BOOMBEVOLKING IN DIE MIDDELANDSE
SEE-KLIMAATSGEBIED VAN SUID-AFRIKA TE WEES?

Onlangse vergelykende studies van die woudplantegroei van die Middelandse Seegebiede van Kalifornië en Suid-Afrika, en algemene beskrywings van die plantegoei van die Middelandse Seegebiede van die wêreld, en die verspreiding van indringerbome en -struie in die fynbosplantegroei van Suid-Afrika, dui daarop dat die Suid-Afrikaanse Middelandse Seegebied 'n veel groter boombevolking behoort te onderhou.

INTRODUCTION

The mediterranean climatic region of South Africa (*sensu lato*, as given by UNESCO-FAO, 1963) is dominated by a sclerophyllous scrub, fynbos, which "is largely devoid of native trees" (Kruger, 1978). Tree vegetation, forest in this case, is more or less restricted to sheltered valleys and patches of rock scree (Campbell & Moll, 1977). Growth of the native trees is probably precluded on fynbos sites by the seasonally severe soil moisture deficits and by the periodic fires that occur on these sites (Kruger, 1978).

There is evidence to suggest that the mediterranean region of South Africa should support an extensive vegetation of trees that can withstand the seasonally severe soil moisture deficits and the periodic fires. Why are such trees absent?

This paper will deal with the evidence indicating that there should be more tree vegetation.

* Present address: Botanical Research Unit, Stellenbosch

** Present address: University of Transkei, Umtata.

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EVIDENCE INDICATING THAT THE SOUTH AFRICAN MEDITERRANEAN REGION SHOULD SUPPORT A MUCH MORE EXTENSIVE TREE VEGETATION

(1) *Semi-detailed comparative studies of the evergreen, broad-leaved, sclerophyllous forests of the mediterranean regions of South Africa and California* (Campbell, McKenzie & Moll, in prep.)

In this recent comparative study of the forests of these regions it is indicated that, even though the climatic and fire conditions are similar, there is a relative lack, in South Africa, of evergreen sclerophyllous forest or woodland at high altitudes (above 800 m), and on low-altitude xeric slopes (Fig. 1). This phenomenon is the case even though the South African mediterranean region has more favourable climatic conditions for the growth of evergreen, broad-leaved, sclerophyllous trees (i.e. a less severe summer drought and a higher annual precipitation—Campbell *et al.*, in prep.).

(2) *General vegetation accounts of mediterranean climatic regions*

From general accounts of the vegetations of mediterranean-type climates it is apparent that the South African region has less extensive evergreen, broad-leaved, sclerophyllous tree formations than any of the other regions. The forest in the South African region was more extensive when European man first settled at the Cape 300 years ago (Sim, 1907; and see the map in Campbell & Moll, 1977, showing the probable distribution of forest on Table Mountain in 1600 A.D.), but this forest (or woodland) was never as extensive as in the other mediterranean regions where climates are similar and where fire is also a feature of the environment. Acocks (1953) mapped almost no forest in the mediterranean region of South Africa on his 1:1 500 000 map of the veld types of South Africa. Under similar climatic conditions in Western Australia, there are extensive areas of tree formations—mainly *Eucalyptus* woodland (Walter, 1973; see also the 1:6 000 000 vegetation map of Australia, Department of National Resources, 1976). The analogous climatic area in Chile has more extensive tree formations (Walter, 1973; E. Moll, pers. obs.), there is no doubt that the area around the Mediterranean Sea once supported extensive *Quercus ilex* forest (Walter, 1973), and finally, California has more extensive tree formations (mainly woodland) than the South African region (see Kuchler's, 1964, 1:3 168 000 map of the potential natural vegetation of the U.S.A., and the U.S. Forest Service vegetation type maps of Southern California).

Other workers have also noted the relative lack of trees in the South African region as compared to other mediterranean regions. Levyns (1961) notes this when comparing the South African and Australian regions. Adamson (in Wicht, 1945) wrote "as compared with Australia or the Mediterranean, a striking dissimilarity is the absence of trees". Kruger (1978) notes that the effective precipitation indices (Bailey, 1958, in Kruger) at many of the South African stations "in

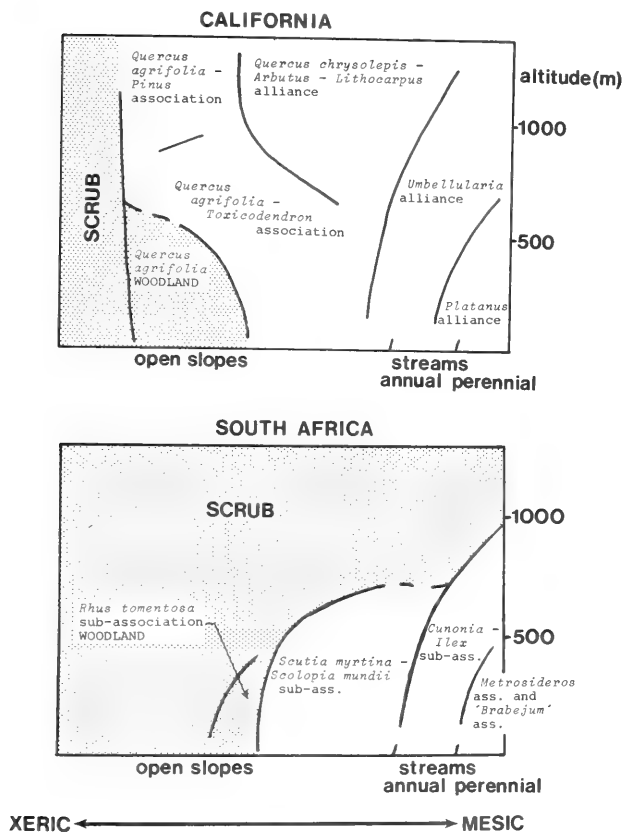


FIG. 1

The proposed relationships of the forest types in California (Campbell, 1979) and South Africa (Campbell and Moll, 1977) to altitude and moisture gradients. The unshaded area represents forest. The shaded area represents scrub.

mountains and wetter valleys have indices over 10 and these stations on other continents, would have a forest cover''.

(3) The spread of introduced trees and shrubs in fynbos

The fynbos is particularly prone to invasion by introduced tall shrubs and trees (e.g. *Acacia* spp., *Hakea* spp., *Albizia* and *Pinus* spp.; see, e.g., Hall & Boucher, 1977). This invasion of introduced tall shrubs and trees does not appear to occur in

the other mediterranean regions (at least in Australia and California), and successful invasion of fynbos by these species "is not dependent on disturbance of the habitat" (Kruger, 1977). There are many reasons why the fynbos is particularly prone to invasion. One possibility is that the invasive trees and tall shrubs have little competition because of the relative absence of native trees in the fynbos.

CONCLUSIONS

If we can accept the suggestion in this paper that the South African mediterranean region should have a more extensive tree formation, what are the reason(s) for this phenomenon? What has caused the absence of trees that can withstand summer soil moisture deficits and periodic fires? Have such trees failed to evolve, and, if so, why? Is the absence of such trees related to the relatively recent activities of man (i.e. in the last 10 000 years) or to the climatic changes of the pleistocene? Furthermore, how is the absence related to the uniqueness of the fynbos biome? The fynbos biome only makes up 0.04 % of the world's vegetated surface and yet is one of the six floristic kingdoms of the world (Oliver, 1977). Questions like these indicate the great need for palaeoecological investigations in fynbos, and detailed comparative studies of all the mediterranean regions of the world.

ACKNOWLEDGEMENTS

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THE ORCHID FLORA OF THE NYIKA PLATEAU

G. WILLIAMSON

ABSTRACT

A brief description of the Nyika Plateau is presented. The composition of the orchid flora is discussed. A check list is included with a cited specimen for each taxon and the habitat for each species is indicated.

UITTREKSEL

DIE ORGIDEË-FLORA VAN DIE NYIKA-PLATO

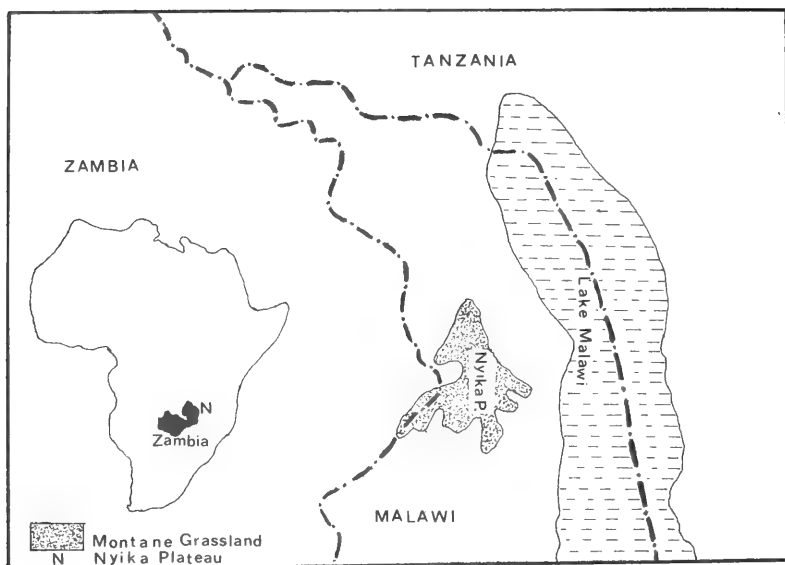
'n Kort beskrywing van die Nyika-plato word gegee. Die samestelling van die Orgideë-flora word bespreek. 'n Kontrolelys word ingesluit met 'n eksemplaar vir elke taksa aangeteken. Die habitat vir elke soort is aangedui.

INTRODUCTION

The Nyika Plateau is situated in South Central Africa close to the northern tip of Lake Malawi. It straddles the borders of Zambia and Malawi, lying approximately 10° 21' and 11° 00' latitude south and 33° 35' and 34° 00' longitude east of Greenwich. The plateau is a western shoulder of the Lake Malawi rift valley formed during the period of earth movements when the Great African Rift Valley was formed. It is very roughly ovoid in shape with a north east extension. The plateau plus the surrounding upland woodland covers an area of approximately 625 sq. km. Legislation includes a protected area within a proclaimed national park of all land above the 1 650 m contour line.

At the transition zone between the wet upland woodlands and the high plateau are found scattered *Brachystegia* woodland elements with occasional secondary montane forest intrusions. Depending on drainage and soil characters, loose *Uapaca-Protea-Phillipia* woodland merging into grassland is frequently encountered. As the altitude increases, the existence of the lower woodland becomes less evident until the pure montane vegetation belt is reached.

The true plateau begins at an altitude of approximately 1 950 m. In this high zone, which is over 2 100 m, exist wide open stretches of montane grassland interspersed with a mosaic of perennial peat bog seepages and dense stands of montane mist forest in the crotches of valleys and on badly drained slopes. Occasionally large high granite or resistant quartzite outcrops rise above the grassland. Over a long period of time organic matter has collected in saucer depressions and deep cracks forming small peat mat seepages on the surfaces of these expansive rock slabs.



Locality of the Nyika Plateau showing the extent of the high montane grasslands. (From *Flora Zambesiaca*).

Spectacular rapids and waterfalls are formed where streams cut through the rim of the plateau. The effective humidity in some of these gorges is especially high allowing for very favourable habitat conditions for the growth of epiphytic plants.

The highest points on the plateau are Nganda, 2 520 m in the north and Kasaramba, 2 460 m in the south east. The forest on Kasaramba is extremely wet, receiving in excess of 187 mm of rain annually and has yielded numerous interesting epiphytes including an endemic orchid genus.

The climate of the plateau is mild and moist with the mean annual maximum temperature in the region of 18.5° C and with a mean annual minimum temperature of approximately 9° C. Low lying areas on the central plateau are often frosted in winter. The whole plateau receives in excess of 140 mm of rain annually. The highest recorded moisture condensation is on the eastern rim where up to 187 mm falls. In the adjacent *Brachystegia* woodlands below the true plateau the annual rainfall fades to 100 mm.

Large herds of game animals, eland, zebra and roan are resident permanently on the plateau but to date do not interfere with the orchid flora.

The soils on the plateau are mainly acidic with the pH ranging from 4 to 5.5, (Williamson samples collected 1968 analysed by Mount Makulu Research Station, Lusaka).

THE ORCHID FLORA

The orchid flora of the high plateau including the adjacent woodlands comprises of 29 genera including some 148 species of which 30 species are epiphytic. The largest genera are *Habenaria* (33 spp.), *Satyrium* (19 spp.), *Disa* (18 spp.) *Eulophia* (11 spp.) and *Disperis* (7 spp.).

The main affinities lie with the East African Montane and Upland orchid floras. The Nyika by virtue of its geographic position is also a link between the Southern and Northern Afro-montane orchid floras; thus there is considerable overlap with species that occur in the Southern Malawi Highlands, the Rhodesian Eastern Districts and even the South African Drakensberg. Due to a long isolation in time there are also some endemics. Approximately 18 forms of life are thought to be endemic including one genus and 6 species of orchids.

The epiphytic genera *Bulbophyllum*, *Polystachya*, *Microcoelia*, *Diaphananthe* and *Aërangis* which occur mainly in Central Tropical Africa are very poorly represented. Similarly the species from the dry Savanna regions are very low in number.

The montane grassland receives such a high level of moisture condensation that species which normally occur in perennial wet bog at lower altitudes thrive in the open Nyika grasslands. A few species which only occur in shaded woodland at lower altitudes also grow in the drier areas of the montane grassland.

CHECK LIST OF ORCHIDACEAE OCCURRING ON THE NYIKA PLATEAU AND ADJACENT WOODLAND

Cited specimens

The collectors' names have been abbreviated as follows:

B M & S	R. Brummitt, Munthali & Synge
G & R	R. Grosvenor and Renz
H	W. D. Holmes
M	A. Moriarty
P	J. Pawek
R	M. Richards
W	G. Williamson
W B & S	G. Williamson, J. S. Ball & B. K. Simon
W & O	G. Williamson & A. Odgers

Herbarium abbreviations are according to the *Index Herbariorum* (Lanjouw and Stafleu, 1964).

The key to the habitats is as follows:

B	perennial wet peat bog seepage on plateau
E	epiphytic
F	montane mist forest
G	dry montane grassland
S	rock seepage on plateau
U	occurring in the adjacent upland <i>Brachystegia</i> woodland
W G	wet montane grassland

Subfamily: **ORCHIDOIDEAE**

Tribe: **ORCHIDEAE**

Subtribe: **ORCHIDINAE**

Holthrix Lindl.			
H. papillosa	Summerh.	W & O 265 (K; SRGH)	G
H. pleistodactyla	Kraenzl.	W 395 (K; SRGH)	G
H. tridactylites	Summerh.	W 394 (K; SRGH)	G
H. buchananii	Schltr.	P 2146 (K)	G
H. puberula	Rendle	P 13716 (K)	U
Neobolusia Schltr.			
N. stolzii	Schltr.	W & O 278 (K; SRGH)	W G
Schwartzkopffia Kraenzl.			
S. lastii	(Rolfe) Schltr.	W 2100 (SRGH)	U
Brachycorythis Lindl.			
B. rhodostachys	(Schltr.) Summerh.	W 207 (K)	B
B. tenuior	Rchb.f.	W B & S 376 (K)	U
B. pleistophylla	Rchb.f. subsp. pleistophylla Summerh.	W 128 (K; SRGH)	U G
Schizochilus Sand.			
S. sulphureus	Schltr.	W B & S 802 (SRGH)	W G S
Cynorkis Thou.			
C. anacamptoides	Kraenzl.		
var. anacamptoides		W 127	B
C. anacamptoides	Kraenzl.		
var. ecalcarata	Cribb	W 233 (K; SRGH)	B
C. kassnerana	Kraenzl.		
subsp. kassnerana		W & O 286 (K; SRGH)	F
C. hanningtonii	Rolfe	W 830 (SRGH)	F
Habenaria Willd.			
Sect. <i>Chlorinae</i>			
H. filicornis	Lindl.	W B & S 796 (SRGH)	W G
H. xanthochlora	Schltr.	W & O 266 (K; SRGH)	G
H. tenuispica	Rendle	W 235 (K)	B

Sect. <i>Pseudoperistylus</i>		
<i>H. petitiانا</i> (Rich.)		
TH. Dur. & Schinz.	W & O 288 (K)	F
Sect. <i>Multipartitae</i>		
<i>H. praestans</i> Rendle	W B & S 806 (SRGH)	verge F G
Sect. <i>Trachypetalae</i>		
<i>H. trachypetala</i> Kraenzl.	W & O 300 (SRGH)	U
Sect. <i>Pentaceras</i>		
<i>H. pubidens</i> Cribb	W & O 280 (K; SRGH)	F
<i>H. parvifolia</i> Summerh.	W B & S 374 (SRGH)	G
<i>H. modica</i> Summerh.	W B & S 364 (SRGH)	G
Sect. <i>Replicatae</i>		
<i>H. williamsonii</i> Cribb.	W & O 283 (K; SRGH)	G
<i>H. kyimbilae</i> Schltr.	W & O 275 (SRGH)	G
<i>H. thomsonii</i> Rchb.f.	W 944 (SRGH)	G
<i>H. sp.</i> (W & O 276) aff.		
<i>thomsonii</i> Rchb.f.	W & O 276 (SRGH)	G
<i>H. Linderi</i> Summerh.	W 944 (SRGH)	G
<i>H. schimperana</i> A. Rich.	W 945 (SRGH)	B
<i>H. weberana</i> Schltr.	W 2162 (SRGH)	G
<i>H. sp.</i> (G & R 1216)	G & R 1216 (SRGH)	G
<i>H. leucoceras</i> Schltr.	W 943 (SRGH)	G
<i>H. sp.</i> (G & R 1180)		
aff. <i>humilior</i> Rchb.f.	G & R 1180 (SRGH)	G
<i>H. retinervis</i> Summerh.	P 13710 (K; MO; MAL)	U
<i>H. diselloides</i> Schltr.	W 387 (K)	G
<i>H. sp. nov.</i> (W & O 273 = W 946)	W & O 273 (SRGH)	G
Sect. <i>Ceratopetalae</i>		
<i>H. stenorhynchos</i> Schltr.	W B & S 813 (SRGH)	B
<i>H. cornuta</i> Lindl.	W B & S 833 (SRGH)	G S
<i>H. gonatosiphon</i> Summerh.	M 35 (MAL)	B
<i>H. clavata</i> (Lindl.) Rchb.f.	W B & S 825 (SRGH)	G
<i>H. sp.</i> (W & O 292)	W & O 292 (K)	G
<i>H. holubii</i> Rolfe	P 13711 (K)	U
Sect. <i>Kryptostoma</i>		
<i>H. goetzeana</i> Kraenzl.	W B & S 378 (SRGH)	U
<i>H. tentaculigera</i> Rchb.f.	W B & S 819 (SRGH)	G
Sect. <i>Diphyllae</i>		
<i>H. sp.</i> (W B & S 375)	W B & S 375 (SRGH)	G
<i>H. macrura</i> Kraenzl.	W B & S 814 (SRGH)	G
<i>H. lithophila</i> Schltr.	H 0234 (K; SRGH)	G
<i>Platycoryne</i> Rchb.f.		
<i>P. protearum</i> (Rchb.f.) Rolfe	W B & S 801 (SRGH)	R
<i>Roeperocharis</i> Rchb.f.		
<i>R. wentzeliana</i> Kraenzl.	W 897 (K; SRGH)	G WG
<i>R. bennettiana</i> Rchb.f.	W 902 (K; SRGH)	WG B
<i>Centrostigma</i> Schltr.		
<i>C. sp.</i> (E. Phillips in P 8092)	P 8092 (K; MAL)	B

Subtribe: DISINAE

<i>Disa</i> Berg.		
<i>D. stolzii</i> Schltr.	W 222 (K)	WG B

<i>Disa erubescens</i> Rendle	W B & S 793 (SRGH)	S B
<i>D. zombica</i> N.E. Br.	W & O 295 (K; SRGH)	W G
<i>D. englerana</i> Kraenzl.	W & O 281 (SRGH)	G
<i>D. welwitschii</i> Rchb.f.	W 226 (K)	B
<i>D. celata</i> Summerh.	W 232 (SRGH)	B
<i>D. ochrostachya</i> Rchb.f.	W 1040 (SRGH)	B W G
<i>D. sp</i> (W B & S 357)	W B & S 357 (SRGH)	G
Sect. <i>Hircicornes</i>		
<i>D. robusta</i> N.E. Br.	W 120 (K; SRGH)	G
<i>D. sp.nov.</i>	W 184 (SRGH)	B
<i>D. hircicornis</i> Rchb.f.	W B & S 821 (SRGH)	B
<i>D. compta</i> Summerh.	W 167 (SRGH)	B
Sect. <i>Aconitoideae</i>		
<i>D. saxicola</i> Schltr.	W B & S 803 (SRGH)	S E F
<i>D. equestris</i> Rchb.f.	W 151 (SRGH)	B
<i>D. sp.nov.</i>	W 223 (SRGH)	G
<i>D. rungweënsis</i> Schltr.	W B & S 363 (K; SRGH)	S
Sect. <i>Herschelia</i>		
<i>D. longilobis</i> Schltr.	W 1041 (SRGH)	G
<i>D. sp.nov.</i>	W 1023 (SRGH)	G
<i>Brownleea</i> Lindl.		
<i>B. parviflora</i> Lindl.	W & O 294 (K; SRGH)	G

Subtribe: SATYRINAE

Satyrium Sw.Sect. *Satyrium*

<i>S. carsonii</i> Rolfe	W B & S 828 (SRGH)	U
<i>S. princeae</i> Kraenzl.	W B & S 367 (K; SRGH)	R W G
<i>S. orbiculare</i> Rolfe	W B & S (SRGH)	U S
<i>S. kitimboënsis</i> Kraenzl.	W B & S 840 (SRGH)	U

Sect. *Leptocentrum*

<i>S. crassicaule</i> Rendle	W 239 (K; SRGH)	B
<i>S. rhynchantoides</i> Schltr.	W 243 (K; SRGH)	S
<i>S. monadenum</i> Schltr.	W 229 (K; SRGH)	W G
<i>S. acutirostrum</i> Summerh.	W & O 267 (K; SRGH)	G
<i>S. neglectum</i> Schltr.	W B & S 373 (K; SRGH)	G
<i>S. buchananii</i> Schltr.	W B & S 799 (SRGH)	W G

Sect. *Chlorocorys*

<i>S. sacculatum</i> (Rendle) Rolfe	W B & S 359 (K; SRGH)	G
<i>S. riparium</i> Rchb.f.	W B & S 824 (SRGH)	G
<i>S. chlorocorys</i> Rolfe	W & O 298 (K; SRGH)	G
<i>S. shirensis</i> Rolfe	W & O 264 (SRGH)	G
<i>S. microcorys</i> Schltr.	W & O 289 (K; SRGH)	W G
<i>S. sphaeranthum</i> Schltr.	W & O 297 (K; SRGH)	W G
Sect. <i>Leucocomus</i>		
<i>S. trinerve</i> Lindl.	W B & S 812 (SRGH)	B W G
<i>S. amblyosaccos</i> Schltr.	W B & S 358 (SRGH)	G
<i>S. breve</i> Rolfe	W 127 (SRGH)	B

Subtribe: CORYCIINAE

Disperis Sw.

<i>D. anthoceros</i> Rchb.f. var. <i>anthoceros</i>	W & O 285 (SRGH)	F
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Disperis nemorosa Rolfe	W & O 269 (K)	F
D. breviloba Verd.	W B & S 362 (SRGH)	G
D. aphylla Kraenzl.	W 888 (SRGH)	F
D. dicerochila Summerh.	W 919 (SRGH)	F
D. kilimanjarica Rendle	W 887 (SRGH)	F E

Tribe: **NEOTTIEAE**Subtribe: **ERYTHRODINAE**

Epipactis Zimm.		
E. africana Rendle	B M & S 126 (K)	F

Tribe: **EPIDENDREAE**Subtribe: **LIPARIDINAE**

Malaxis Sw.		
M. schliebenii (Mansf.) Summerh.	W 858 (K)	U
M. katangensis Summerh.		
var. katangensis	W 247 (K)	U
Liparis L.C. Rich.		
L. neglecta Schltr.	W B & S 847 (SRGH)	F
L. mulindana Schltr.	W B & S 377 (SRGH)	U

Subtribe: **POLYSTACHYINAE**

Polystachya Hook		
Sect. Caulescentes		
P. transvaalensis Schltr.	W 823 (SRGH)	F E
Sect. Affines		
P. malilaensis Schltr.	W 125 (SRGH)	F E
Sect. Superpositae		
P. fusiformis (Thou.) Lindl.	W B & S 842 (SRGH)	F U E
Stolzia Schltr.		
S. williamsonii Cribb	W B & S 370 (K)	F E
S. repens (Rolfe) Summerh.	W 237 (K; SRGH)	U E
S. compacta Cribb		
subsp. compacta	W B & S 371 (K; SRGH)	F E

Subtribe: **BULBOPHYLLINAE**

Bulbophyllum Thou.		
B. sandersonii (Oliv.) Rchb.F.	W B & S 845 (SRGH)	F U E
B. rugosibulbum Summerh.	W B & S 835 (SRGH)	U E
B. cochleatum Lindl.	W B & S 839 (SRGH)	F U E

Subtribe: **NERVILINAE**

Nervilia Commerson ex Gaud.		
N. pectinata Cribb (leaf only)	W 2102 (SRGH)	F

Tribe: VANDAE

Subtribe: CYRTOPODIINAE

<i>Eulophia</i> R. Br. ex Lindl.		
<i>E. thomsonii</i> Rolfe	W 148 (SRGH)	G
<i>E. monticola</i> Rolfe	R10399 (K; SRGH)	G
<i>E. ovalis</i> Lindl. subsp.		
<i>bainsii</i> (Rolfe) Hall	W 236 (SRGH)	G
<i>E. odontoglossa</i> Rchb.f.	W 1724 (SRGH)	G
<i>E. ukingensis</i> Schltr.	W B & S 366 (K; SRGH)	B
<i>E. corallorhiziformis</i> Schltr.	W 1042 (SRGH)	B
<i>E. streptopetala</i> Lindl.	W 1007 (SRGH)	F
<i>E. coeloglossa</i> Schltr.	W 1044 (SRGH)	B
<i>E. cucullata</i> (Afz. ex Sw.) Steud.	P 581	
	P 3261 (SRGH) ??	U
<i>E. arenicola</i> Schltr.	W 1039 (SRGH)	G (on rocks)

Subtribe: ANGRAECINAE

<i>Angraecum</i> Bory		
<i>A. sacciferum</i> Lindl.	H 088 (SRGH)	F E
<i>A. sp.</i> (W B & S 385)	W B & S 385 (K)	F E
<i>Holmesia</i> Cribb		
<i>H. parva</i> Cribb	W B & S 383 (K)	F E

Subtribe: AËRANGIDINAE

<i>Microcoelia</i> Lindl.		
<i>M. stolzii</i> (Schltr.) Summerh.	W 2103 (SRGH)	F E
<i>Mystacidium</i> Lindl.		
<i>M. tanganyikense</i> Summerh.	W B & S 369 (SRGH)	F E
<i>Diaphanranthe</i> Schltr.		
Sect. <i>Rhipidoglossum</i>		
<i>D. pulchella</i> Summerh.	W 238 (SRGH)	F U E
<i>D. xanthopollinia</i> (Rchb.f.) Schltr.	W 920 (SRGH)	U E
<i>D. oxycenron</i> Cribb	W B & S 381 (K)	F E
<i>Bolusiella</i> Schltr.		
<i>B. iridifolia</i> (Rolfe) Schltr.		
subsp. <i>picea</i> Cribb	W 1056 (K)	F E
<i>Aërangis</i> Rchb.f.		
<i>A. sp. nov.</i> (W 1094)	W 1094 (K)	F E
<i>Rangaëris</i> Summerh.		
<i>R. musicola</i> (Rchb.f.) Summerh.	W B & S 841 (SRGH)	U E (on rock)
<i>Tridactyle</i> Schltr.		
<i>T. inaequilonga</i> (De Wild.) Schltr.	W 123 (K; SRGH)	F E
<i>T. tricuspid</i> (Bolus) Schltr.	W & O 284 (K)	F E
<i>T. sp. nov.</i> (W 277)	W 277 (K; SRGH)	F E
<i>T. citrina</i> Cribb	W 230 (K; SRGH)	U E
		(On protea)
<i>Cardiochilos</i> Cribb		
<i>C. williamsonii</i> Cribb	W 388 (K)	F E

In addition to the above list the following orchids have been observed but not collected thus no voucher specimens exist:

Disperis reichenbachiana Rchb.f. Chisenga Falls.

Polystachya holmesii Cribb. On trees below plateau.

Bulbophyllum mahonii Rolfe. Woodland close to park entrance.

B. buntingii Rendle. Woodland below plateau.

Nervilia humilis Schltr. Woodland below plateau.

N. adolphii Schltr. Chisenga Falls.

N. kotschyi (Rchb.f.) Schltr. Woodland near Chisenga Falls.

Tridactyle teretifolia Schltr. Woodland adjacent to Chisenga Falls.

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NOTES ON *PROTEA* IN SOUTH AFRICA

J. P. ROURKE

(*Compton Herbarium, Kirstenbosch*)

ABSTRACT

Protea minor (Phill.) Compton is synonymous with *Protea longifolia* Andr. and the species previously referred to in literature as *P. minor*, being left without a name, is described here *de novo* as *Protea pudens* Rourke. New combinations, *Protea aurea* (Burm.f.) Rourke, and *Protea aurea* (Burm.f.) Rourke spp. *potbergensis* (Rourke) Rourke, are made.

UITTREKSEL

AANTEKENINGE OOR *PROTEA* IN SUID-AFRIKA

Protea minor (Phill.) Compton is sinoniem met *Protea longifolia* Andr. en die soort wat voorheen in die literatuur as *P. minor* bekend was is dus sonder 'n naam en word hier *de novo* as *Protea pudens* Rourke beskryf. Nuwe kombinasies, *Protea aurea* (Burm.f.) Rourke en *Protea aurea* (Burm.f.) Rourke spp. *potbergensis* (Rourke) Rourke word gemaak.

1. *The identity of Protea minor* (Phill.) Compton

When Compton (1944) described *Protea minor* he raised *Protea longifolia* Andr. var. *minor* Phill. in Fl. Cap. 5: 575 (1912) to specific rank. The designated type of *P. longifolia* Andr. var. *minor* Phill. (*Bolus* 7860 in BOL) is a small form of *P. longifolia* Andr. However, the nine additional specimens cited by Compton, as well as his published illustration of *P. minor*, all clearly refer to another species. *P. minor* has always been interpreted in terms of Compton's illustration and the nine additional cited specimens, but never by reference to the type of the name (*Bolus* 7860). Vogts (1966) drew attention to this regrettable anomaly and correctly suggested that separate status for the taxa involved would prove necessary. Thus *P. minor* (Phill.) Compton must be placed in synonymy under *P. longifolia* Andr. Consequently, the species previously known as *P. minor* Compton is left without a name and is therefore described here *de novo*.

***Protea pudens* Rourke, sp. nov.;** *P. longifoliae* Andr. affinis, sed differt habitu procumbentibus, caulibus serpentibus, foliis secundis linearibus vel perangustis linearibus—spatulatis, 2–5 mm latis, 60–140 mm longis, inflorescentiis pusillus, 50–80 mm longus, stylis 30–45 mm longis, et bracteis roseis.

A sprawling procumbent shrub up to 1 m in diam., to 400 mm in height with a single main stem producing suberect to prostrate branches, often trailing along

ground. *Stems* 3–5 mm in diam., densely and cinereously puberulous initially, later glabrous. *Leaves* linear to very narrowly linear-spathulate, 60–140 mm long, 2–5 mm wide, length variable on same shoot, glabrous but margins occasionally ciliate; secund to subsecund, subfalciform to straight. *Inflorescence* campanulate, 50–80 mm long, 30–60 mm wide. *Involucral receptacle* conic-depressed, 10–20 mm wide, 5–10 mm high. *Involucral bracts* 4–5 seriate, outer series broadly ovate—obtuse, 6–10 mm wide, 6–10 mm long, glabrous but margins ciliate; inner series ovate-oblong, acute to narrowly oblong acute to lanceolate, usually glabrous but innermost series occasionally minutely sericeous. *Perianth* straight, 40–60 mm long, densely villous except for tube region; tube 5–8 mm long, glabrous, quadrangular, claws very densely villous, the inner lips of the perianth claws also densely villous, indumentum white; the three adaxial perianth limbs 5–8 mm long prolonged into 10–18 mm long, densely plumed awns, white proximally but with purple/black indumentum distally, the median adaxial awn markedly shorter than 2 lateral awns. *Anthers* 3, fertile; the free abaxial perianth limb subulate, densely villous with white indumentum, anther reduced to a staminode. *Style* 30–45 mm long, straight to very slightly adaxially arcuate, swollen, ancipitous and puberulous proximally, tapering, becoming terete and glabrous distally. *Pollen presenter* 5–7 mm long, slender, curved, prominently geniculate at junction with style, apex capitellate. *Ovary* obconic, 5 mm long, covered with 20 mm long, straight, tawny trichomes. *Hypogynous scales* narrowly ovate, 1.5 mm long.

Type Material: Between Heuning Rug and Mierkraal, Bredasdorp, 1/8/1973, J. P. Rourke 1393 (NBG, holotype; STE, PRE, BOL, K, MO, S, isotypes).

Protea pudens is distinguished from related species by its procumbent growth habit with trailing stems bearing linear to very narrowly linear-spathulate leaves, 2–5 mm wide, 60–140 mm long, secundly arranged, the deep pink involucral bracts and short styles, 30–45 mm long.

SPECIMENS EXAMINED

CAPE PROVINCE—3419 (Caledon): The Poort, 8 miles on the road from Bredasdorp to Elim (-DB), April, *L. Bolus* 20571 (BOL); sandy edges of vle between Bredasdorp and Elim, Sept., *Leighton* 21139 (BOL, K); Mierkraal, Sept., *Jordaan* 1128 (STE); between Heuning Rug and Mierkraal, Aug., *Rourke* 1393 (NBG, STE); hills about Elim, July, *Guthrie* 3865 (NBG); flats 5 miles west of Mierkraal, April, *Oliver s.n.* (NBG 66822); near Springfield, July, *Lord de Saumarez s.n.* (NBG 82738); between Heuning Rug and Mierkraal, Sept., *Rourke* 1220 (NBG); Bredasdorp district, Sept. 1932, *Valpy s.n.* (SAM 50432); Bredasdorp Poort, Sept., *Compton* 4786 (NBG); Bredasdorp div., July 1895, *H. Bolus s.n.* (BOL 20029); midway between Kersgat and Pietercillieskloof, Aug., *Rourke* 1392 (NBG); *Note:* this collection is possibly a hybrid with *P. longifolia* Andr.

Dubious Locality: Kleinmond, *L. G. Gray s.n.* (NBG 1547/29)

2. *Protea aurea* (Burm.f.) Rourke, the correct name for a species previously known as *P. longiflora* Lam.

In an earlier note (Rourke, 1973) it was suggested that *Leucadendron aureum* Burm.f. be rejected under Article 70 of the International Code of Botanical Nomenclature, as the name was based on two discordant elements belonging to two different genera. However, it is apparently possible to select one of these elements as a satisfactory type. *Leucadendron aureum* Burm.f. is thus the earliest legitimate name applied to the species previously known as *Protea longiflora* Lam. Accordingly, the combinations *Protea aurea* (Burm.f.) Rourke and *Protea aurea* (Burm.f.) Rourke, ssp. *potbergensis* (Rourke) Rourke, are now made.

***Protea aurea* (Burm.f.) Rourke, comb. nov.**

Leucadendron aureum Burm.f., Prodr. Fl. Cap.: 4 (1768)—pro parte;—basionym. Type: Boerhaave, Ind. Alt. Plant. t. 199 (1720) as to flowering branch labelled A, B, C, D, E, F, I and K (lectotype);—excluding cone and fruits labelled G, H, L and M.

Protea longiflora Lam., Tabl. Encycl. 1: 234 (1792); Phill. & Stapf. in Fl. Cap. 5: 577 (1912); Rourke in Flower. Pl. Afr. 43: t. 1704 (1976). Type: Cape of Good Hope, without collector, in herb. Lamark (P.—LA!).

***Protea aurea* (Burm.f.) Rourke ssp. *potbergensis* (Rourke) Rourke, comb. nov.**

Protea longiflora Lam. ssp. *potbergensis* Rourke in Jl S. Afr. Bot. 44 (4): 378 (1978) Type: Potberg, Rourke 273 (NBG holo.!, PRE, BOL, MO, K, S, iso.).

ACKNOWLEDGMENTS

The author is indebted to Dr D. J. B. Killick for reading the manuscript and for much helpful advice.

REFERENCES

- COMPTON, R. H., 1944. *Protea minor* Compton. Jl S. Afr. Bot. 10: 1–4.
ROURKE, J. P., 1973. The use of the name *Leucadendron aureum* Burm.f. Jl S. Afr. Bot. 39: 273–276.
VOGTS, M. M., 1966. *Protea minor*. Flower. Pl. Afr. 37: t.1462.



BOOK REVIEWS

FLORA OF SOUTH AUSTRALIA, Part I (Third Edition), by J. M. Black, revised and edited by John P. Jessop, with pp. 466, 467 line drawings and 16 full colour plates: Adelaide: Government Printer, 1978. Aust. \$16,90.

John Jessop, a gain to Australia from South Africa, must have felt very much at home while editing this first volume of the updated flora of South Australia. Of the 38 species of Iridaceae listed, no less than 33 are indigenous to South Africa! Early travellers from Europe made full use of their stopover at the Cape to enrich the sandy areas of Australia.

From Lycopodiaceae to Orchidaceae, the scope of the present volume, we share 153 genera in common (out of a total of 277), a feature which makes this book of interest to South Africans.

J. M. Black's classic work on the flora of South Australia is in the process of being updated once again and this first volume will be especially welcomed by Australian botanists and informed laymen.

D. G. Frodin remarked in the *Gardens' Bulletin, Singapore*, (Vol. XXX, 1977: 239) that the "most satisfactory style for a Flora at the present time should be one of conciseness and practicality". This, and Bentham's plea for "correctness and clearness of method and language" were faithfully adhered to by the late Dr Black, and the present volume continues in the same vein.

In this edition three new species and eight new combinations are published. For the most part species' descriptions have been updated rather than revised, as mentioned by Jessop in his introduction. However, keys have been substantially rewritten and the indented system used is clear and works well.

New features include references to the place of publication of species as well as to relevant illustrations. Reference is made to recent revisions of genera. Flowering times and the range of distribution have been added. Many common names have been included, not all of which are in general use in South Australia as they have been culled from J. H. Willis's *Handbook to Plants in Victoria*.

Many new line drawings have been added and there is approximately one to each page of text. The detailed orchid drawings by L. Dutkiewicz are very good but all drawings have had to be so reduced in size that they cannot compare with the illustrations in our own *Flora of Southern Africa*. However they will certainly be a useful guide to identification.

The 16 full-page plates in coloured pencils by C. E. Woolcock are a pleasant addition but probably account for some of the increased price of this edition.

The book is a convenient size for taking into the field but the very attractive cloth cover, being mainly white, would soon show the marks of any such foray. Good quality paper has been used and the print is clear if rather small. Variations in type are clear and useful.

There is a good glossary and useful tips on the collection of specimens, in the beginning of the book. At the back is an index, only to families and genera (as in the *Flora of Natal*). On the inside of the back cover there is a map of the state of South Australia divided into the regions used by their herbarium. The area covered is approximately the same as that of the Republic of South Africa.

This volume has been produced with commendable speed and the editor and his colleagues are to be congratulated on their work. It is hoped that volumes 2, 3 and 4 will follow without too much delay.

This work will be of tremendous value to all those concerned with the flora of South Australia and neighbouring areas. It will also be a useful companion to the subsequent volumes in which some of our "green cancers" will feature.

PAULINE FAIRALL

AN ILLUSTRATED GUIDE TO POLLEN ANALYSIS, by P. D. Moore and J. A. Webb, with pp. 133. Hodder & Stoughton, 1978. (P.O. Box 702, Mill Road, Dunton Green, Sevenoaks, Kent, TN13 2YD.) £8.50 (board), £4.95 (unibook).

The relatively young science of Palynology (the study of pollen grains and spores) which is practiced by many specialists all over the world in connection with past vegetation and climatic changes is becoming increasingly important in such disciplines as archaeology, pedology, taxonomy and phytogeography. It also has important applications in the fields of aerobiology with regard to human health, and melitopalynology concerning the study of honey. Moreover, in Europe there has in recent years been a demand for courses in palynology in high schools. In view of these developments the authors have compiled a book which embraces the many interesting facets and potentialities of pollen analysis in the hope of further stimulating research in this field of science.

This book of 133 pages is an excellent introduction to the study of the pollen grains of Angiosperms and Gymnosperms as well as the spores of the cryptogams. While of very high standard the book is written in a simple, lucid and concise style and is most interesting. The authors have succeeded in giving a total synthesis of a vast amount of data on this discipline including the development of this field of research and the new advances. The book also has many valuable practical assets and can be regarded as the most up to date account on palynology and includes many important references.

In the first chapter the potentialities of pollen analysis are discussed especially with regard to the study of past vegetation changes which can be dated and which form the basis for the reconstruction of climatic history. This is followed by a very useful and critical consideration of the types of deposits which can be analysed. In Chapter 3 the different methods of collecting samples from the stratified sequences are discussed together with the various chemical treatments necessary for the extraction of the palynomorphs from the matrix before mounting on slides. A very important chapter is the one on the structure and sculpturing of the pollen and spore walls as these form the basis for accurate identification of a vegetation type at a particular point in time. In this connection the value of transmission and scanning electronmicroscopy in addition to light microscopy is stressed. The complicated existing terminology concerning the pollen and spore wall is well sorted out and good illustrations and micrographs abound. The subsequent chapter provides an extremely useful and extensive pollen and spore key of many well-known genera together with a glossary. Of particular significance are the chapters in which the methods of pollen counting, pollen diagram construction and the interpretation of the pollen zones are critically discussed. The last chapter considers the future of pollen analysis.

For the valuable information provided in this book it is not expensive and it should certainly be acquired by all those interested in pollen and spores.

J. A. COETZEE

TROPICAL TREES AND FOREST: AN ARCHITECTURAL ANALYSIS, by F. Hallé, R. A. A. Oldeman and P. B. Tomlinson, with pp. xvii + 441, 111 figures and 605 references. Berlin, Heidelberg, New York: Springer-Verlag, 1978. Price U.S.\$62.50.

An architectural approach to trees and forests is a relatively new idea. Many of its concepts appear strange to the uninitiated; there is also a new terminology to be learnt. Once the initial reluctance to accept new things has been overcome this approach allows the familiar to be viewed through new eyes.

The authors have put together a highly competent synthesis of existing knowledge in this field which will serve as a foundation for future work.

The book consists of five chapters. The first outlines the new approach, defines the architectural concept of tree growth and gives a resumé of the botanical richness of the tropics.

The second chapter gives the ground work for the concept of architectural models in the formation of trees. The various stages of development from the seedling to the mature tree

are discussed. Rhythmic and continuous growth in terminal and lateral meristems, branching, flowering and secondary thickening are considered, all in relation to the trees architecture.

Chapter three describes the inherited architecture of the tree. The 24 different models, each named after a prominent worker in the field, are presented in an illustrated dichotomous key which is remarkably easy to follow, at least in theory. Examples and descriptions of each model are given and discussed.

Chapter four deals with the tree's response to its environment, "opportunistic tree architecture", and introduces the concept of energy exchange as a means of understanding the state of the forest.

The final chapter brings all these concepts together in the architecture of the forest. Three examples of actual plot descriptions are given from tropical forests. A description of "Sylvigenesis", which is defined as "the processes by which forest architecture is built", concludes the text. An useful glossary and full species and subject indices are given.

Several concepts are initially difficult for a forester to accept: the authors' views of what constitutes a tree are very broad; the idea that tree architecture is not taxonomically orientated comes as a surprise. Not only can different members of a family exhibit different architecture but differences can even occur at species level. The authors are at pains to stress that the well-known temperate tree is abnormal in the sense that its growth forms and resting periods are strictly defined. The floristically much richer, less inhibited trees of the tropics exhibit a much wider number of growth forms and growing periods and should be considered to be normal.

The book is well produced, the text is readable and the figures are clear. They are an invaluable aid to the understanding of the concepts presented.

Printers devils occur but the text is remarkably free from this sort of problem.

Minor points of disagreement with the authors such as:

breast height is more often 1,3 m than 1,4 m;

Araucaria cunninghamii should be Massart's model not Rauh's;

Eucalyptus globulus does not regenerate from root suckers but from lignotubers;

did nothing to distract from the overall fascination of the ideas presented.

Although this book should be prescribed reading for final year undergraduate students in botany, ecology and forestry, its price will put it beyond the reach of the average student.

D. G. M. DONALD

PHYSIOLOGY AND BIOCHEMISTRY OF SEEDS IN RELATION TO GERMINATION, VOL. I: DEVELOPMENT, GERMINATION AND GROWTH, by J. D. Bewley and M. Black, with pp. ix + 306, 122 figs. and 41 tables. Berlin, Heidelberg, New York: Springer-Verlag, 1978. Cloth DM 90. US\$45.00.

This book is part of a two-volume treatise. If the standard of volume 2 equals that of the first, the set will constitute a most comprehensive and refreshingly novel presentation of the known facts about the physiology of seeds and their germination in which attention is repeatedly drawn to deficiencies in our knowledge. The material is attractively presented and the authors have a writing style which ensures pleasant reading. The text is almost devoid of printing errors. Each chapter is concluded with two reference lists—one to articles of general interest and the other to research reports. The latter invariably is extensive and up to date. Unfortunately the titles of the research reports do not appear in the list of references.

The illustrations are sufficient, neat and clear. In addition to an extensive subject index, the book also contains an author index and a glossary and index of English and botanical plant names.

Although undergraduates should find the book valuable as a reference work, it will be used mainly by post-graduate students and research workers.

After an informative introductory chapter, the structure of seeds and the kinds of reserve substances that occur in seeds are concisely discussed without going into great detail. This

is followed by a lengthy chapter on seed maturation in which the biosynthesis of starch, protein and fats and oils receive considerable attention. A discussion on the influence of hormones such as the gibberellins, auxins, cytokinins and abscisic acid on seed development concludes the chapter.

Aspects of the water relations of seeds which are not often mentioned in textbooks feature prominently in the chapter which is devoted to the uptake of water by seeds and seedlings.

Chapter 5 is entitled: "Biochemistry of germination and growth." It contains a rigorous treatment of various aspects of respiration, nucleic acid and protein synthesis. In contrast to the critical approach which the authors generally employ, they uncritically discuss work which has been done with the so-called C_0/C_1 ratio method in attempts to establish the relative importance of the glycolytic and pentose phosphate respiratory routes in seeds and seedlings.

In the penultimate chapter the mobilization of reserve substances from the cotyledons or endosperm of seeds to the developing organs of the seedling is discussed. Substances such as alkaloids whose physiological importance is largely a matter of conjecture are not discussed. A weakness of the chapter is the omission of a discussion of the accumulation of amino acid amides and ammonia in seeds during germination under conditions that are conducive to etiolation because such conditions probably often prevail in nature. In general however, the discussion on the mobilization of reserve carbohydrates, proteins and especially fats and oils is done in a masterly and thorough way and is up to date.

The final chapter is devoted to the hormonal control of the mobilization of reserve substances in germinating seeds. Due to a lack of information on the subject, the discussion is devoted almost exclusively to the interaction of the gibberellins and α -amylase as has been studied extensively in germinating cereal grains.

N. GROBBELAAR

PRODUCTION ECOLOGY OF BRITISH MOORS AND MONTANE GRASSLANDS, edited by O. W. Heal and D. F. Perkins assisted by W. M. Brown, with pp. xii, 426 + 132 figures and 145 tables. Berlin, Heidelberg, New York: Springer-Verlag, 1978. Volume 27 in the series "Ecological Studies" edited by W. D. Billings, F. Golley, O. L. Lange and J. S. Olsen, Cloth DM 108, US\$54.00. ISBN 3 540 08457 6.

The Moor House National Nature Reserve was selected in 1965 by the U.K. IBP PT subcommittee as the main site for studies on moorland communities. Although moorlands are not strictly within the definition given for tundra, they are exposed to severe climatic conditions and moorland communities therefore have more in common with tundra than with the other major world biomes as recognised in the IBP (i.e. woodland, grassland and aridland). As such there is little of direct relevance in this volume for most South Africans, with the exception of those concerned with Afro-montane areas and with some of those concerned with heathland nutrition. Nevertheless, the volume is well presented and is a must for any scientific library.

The book is divided into 20 chapters, with separate sections dealing with the Moor House Programme and with supporting studies on the Dwarf Shrub Communities and Snowdonia Grasslands. In general the text is a thorough and detailed summary of moorland work done since 1965. All important aspects of ecosystem structure and function are well dealt with, and in this respect the text is useful background for anyone attempting an ecosystem study or for the teacher who wants relatively simple examples for his students.

The moorland system is basically a fairly simple system with only a handful of angiosperm species present. This simplicity is complicated by the low nutrient environment and grazing management pressures—so the study encompassed by the book is both academic and applied, which makes a useful combination. There are particularly good chapters on field estimates of primary production; the physiological aspects of bog

production; microbial populations in peat; the productivity of a *Calluna* heathland in southern England; primary production, mineral nutrients and litter decomposition in the grassland ecosystem; the grazing intensity and productivity of sheep in the grassland ecosystem; and on the distribution and transfer of energy and nutrients in the *Agrostis-Festuca* grassland ecosystem.

The overall appearance, quality and accuracy of the text; quality, accuracy and relevance of the illustrative matter; and the balance between illustrations and text are all of the highest standard. There is a very good bibliography and the volume is well indexed.

E. J. MOLL

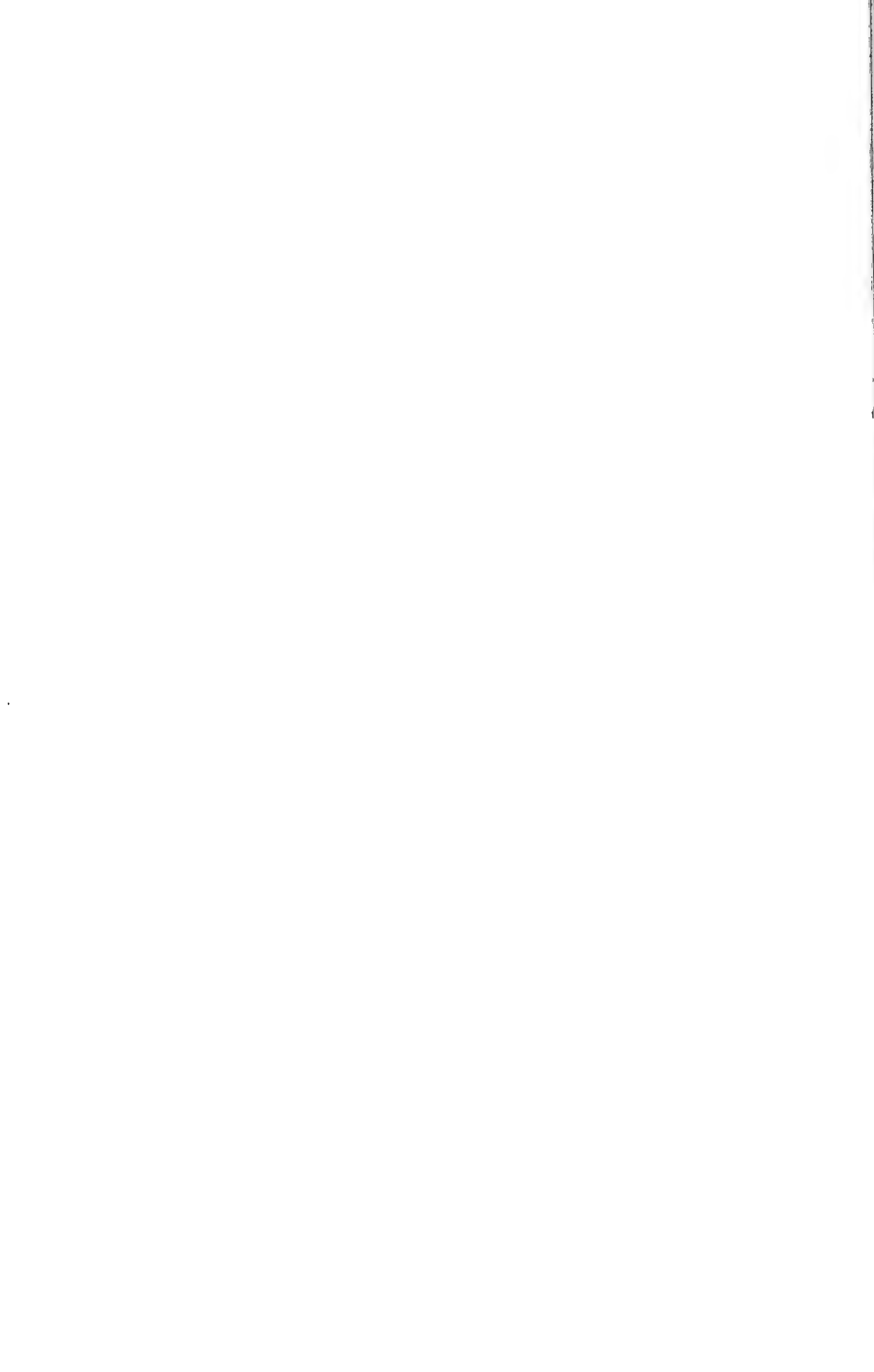


ANNOUNCEMENT

A National Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation will be held at the Hyatt Regency Hotel in Lexington, Kentucky during the period December 4-7, 1979.

Six mini-courses scheduled for December 4 will address important topics in hydrology, sediment control, and reclamation. These include Predicting Sediment Yield From Surface-Mined Land, Reservoir Sedimentation and Chemical Treatment, Groundwater Monitoring, Surface Mine Revegetation, Spoil Testing and Analysis, and Principles of Hydrology.

Concurrent technical sessions beginning on December 5 will include approximately 60 papers in the areas of hydrology, sedimentology, and reclamation. A general session will concern PL 95-87. Limited exhibit space is available. A detailed program and registration information will be available on August 15, 1979. Contact Dr. Stanley Carpenter, Department of Forestry, University of Kentucky, Lexington, Kentucky 40546, U.S.A., (606) 258-4609, for information.



JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 45

1979

INDEX OF PLANT NAMES

Note: Plant names appearing in tables or lists are not included in this index. Page references to new taxa are printed in bold type. An asterisk indicates an illustration.

	PAGE		PAGE
<i>Abutilon fruticosum</i> Guill. & Perr.	*106	<i>Ferraria foliosa</i> Lewis	336, *337
<i>Acacia redacta</i> J. H. Ross	11, *18	<i>F. glutinosa</i> (Bak.) Rendle *302, *306, 329,	
<i>Acmadenia argillophila</i> Williams	160 ,		330
	*161, *162	<i>F. kamiesbergensis</i> De Vos	362 , *363
<i>A. rupicola</i> Williams	163 , *165	<i>F. schaeferi</i> Dinter	*302, 344, *345
<i>A. tenax</i> Williams	166 , *168	<i>F. uncinata</i> Sweet	*298, 365
<i>Allium cepa</i> L.	139	<i>F. uncinata</i> Sweet subsp. <i>macrochlamys</i>	
<i>Avicennia marina</i> (Forsk.) Vierh.	133	(Bak.) De Vos	*368, 369
		<i>F. uncinata</i> Sweet subsp. <i>uncinata</i> ..	366, *368
<i>Babiana virginea</i> Goldblatt	82 , *83	<i>Galaxia alata</i> Goldblatt	418 , *419
<i>Blechnum australe</i> L.	221	<i>G. albiflora</i> Lewis	*420, 421
<i>B. capense</i> (L.) Schlechtend.	221	<i>G. barnardii</i> Goldblatt	398 , *399
<i>B. punctulatum</i> Sw.	221	<i>G. ciliata</i> Persoon	408
<i>B. sylvaticum</i> Schelpe	221	<i>G. citrina</i> Lewis	405, *406
<i>Caralluma acutiloba</i> N.E.Br.	80	<i>G. fugacissima</i> (L.f.) Druce	416, *416
<i>C. hottentotorum</i> N.E.Br.	79	<i>G. grandiflora</i> Andr.	407
<i>C. ortholoba</i> Lavranos	79	<i>G. luteo-alba</i> Goldblatt	410 , *411
		<i>G. ovata</i> Thunb.	412, *413
<i>Dioscorea sylvatica</i> Eckl.	63	<i>G. stagnalis</i> Goldblatt	414
<i>Diosma arenicola</i> Williams	*172	<i>G. variabilis</i> Lewis	403, *404
<i>D. haelkraalensis</i> Williams	172 , *175	<i>G. versicolor</i> Salisb. ex Klatt	400, *400
<i>D. pedicellata</i> Williams	175 , *179, *180	<i>Gladiolus delpierrei</i> Goldblatt	84 , *85
<i>D. strumosa</i> Williams ..	180 , *182, *183, *184	<i>Grewia avellana</i> Hiern	*108
		<i>G. occidentalis</i> L.	*109
<i>Eragrostis curvula</i> (Schrad.) Nees	231	<i>G. vernicosa</i> Schinz	*108
<i>Euchaetis cristagalli</i> Williams	147 , *150	<i>Hermannia desertorum</i> Eckl. & Zeyh.	*109
<i>E. esterhuysenae</i> Williams 150 , *153, *154,		<i>H. elliptiana</i> (Harv.) K. Schum.	*109
	*155	<i>H. rudis</i> N.E.Br.	*109
<i>E. vallis-simiae</i> Williams	156 , *158, *159	<i>H. trifoliata</i> L.	*108
<i>Eugenia verdoorniae</i> Van Wyk	273 , *276	<i>Ixia thomasiae</i> Goldblatt	87 , *88
<i>Ferraria brevifolia</i> G. J. Lewis	369, *371	<i>Lachenalia bolusii</i> Barker	193 , *194
<i>F. crispa</i> Burm. ..	*302, *306, *308, *309, 338	<i>L. latimeriae</i> Barker	196 , *197
<i>F. crispa</i> Burm. subsp. <i>crispa</i>	*339, 341	<i>L. macgregori</i> Barker	199 , *200
<i>F. crispa</i> Burm. subsp. <i>nortierii</i> De Vos ..	343	<i>L. margaretae</i> Barker	202 , *203
<i>F. densepunctulata</i> De Vos	*308, 346	<i>L. marginata</i> Barker	204 , *205
<i>F. divaricata</i> Sweet	*299, *306, *308,	<i>L. martinae</i> Barker	207 , *208
	*309, 354	<i>L. maximiliani</i> Schltr. ex Barker ..	209 , *210
<i>F. divaricata</i> Sweet subsp. <i>arenosa</i> De		<i>L. polypodantha</i> Schltr. ex Barker ..	212 , *212
Vos	358	<i>L. stayneri</i> Barker	214 , *215
<i>F. divaricata</i> Sweet subsp. <i>aurea</i>		<i>L. ventricosa</i> Schltr. ex Barker	216 , *217
De Vos	359 , *360	<i>Malva neglecta</i> Wallr.	*106
<i>F. divaricata</i> Sweet subsp. <i>australis</i>		<i>M. parviflora</i> L.	*106
De Vos	*360, 361	<i>Melhania acuminata</i> Mast.	*108
<i>F. divaricata</i> Sweet subsp. <i>divaricata</i> ..	356	<i>M. forbesii</i> Planch. ex Mast.	*106
<i>F. ferrariola</i> (Jacq.) Willd.	*298, *302,		
	*306, *308, *309, 350, *351		

	PAGE		PAGE
<i>Pelargonium hirsutum</i> (Burm.f.) Ait. . . .	379	<i>Saccharomyces cerevisiae</i> Hansen	263
<i>Phaseolus vulgaris</i> L.	244, 250, 258	<i>Tapinanthus gracilis</i> Toelken & Wiens . .	224
<i>Protea aurea</i> (Burm.f.) Rourke	471	<i>T. natalitius</i> (Meisn.) Danser	224
<i>P. aurea</i> (Burm.f.) Rourke subsp. <i>pot-</i>		<i>Tulbaghia cominsii</i> Vosa	128, *130, *131
<i>bergensis</i> (Rourke) Rourke	471	<i>Xerocladia viridiramis</i> (Burch.) Taub. . . .	14
<i>P. pudens</i> Rourke	469		





